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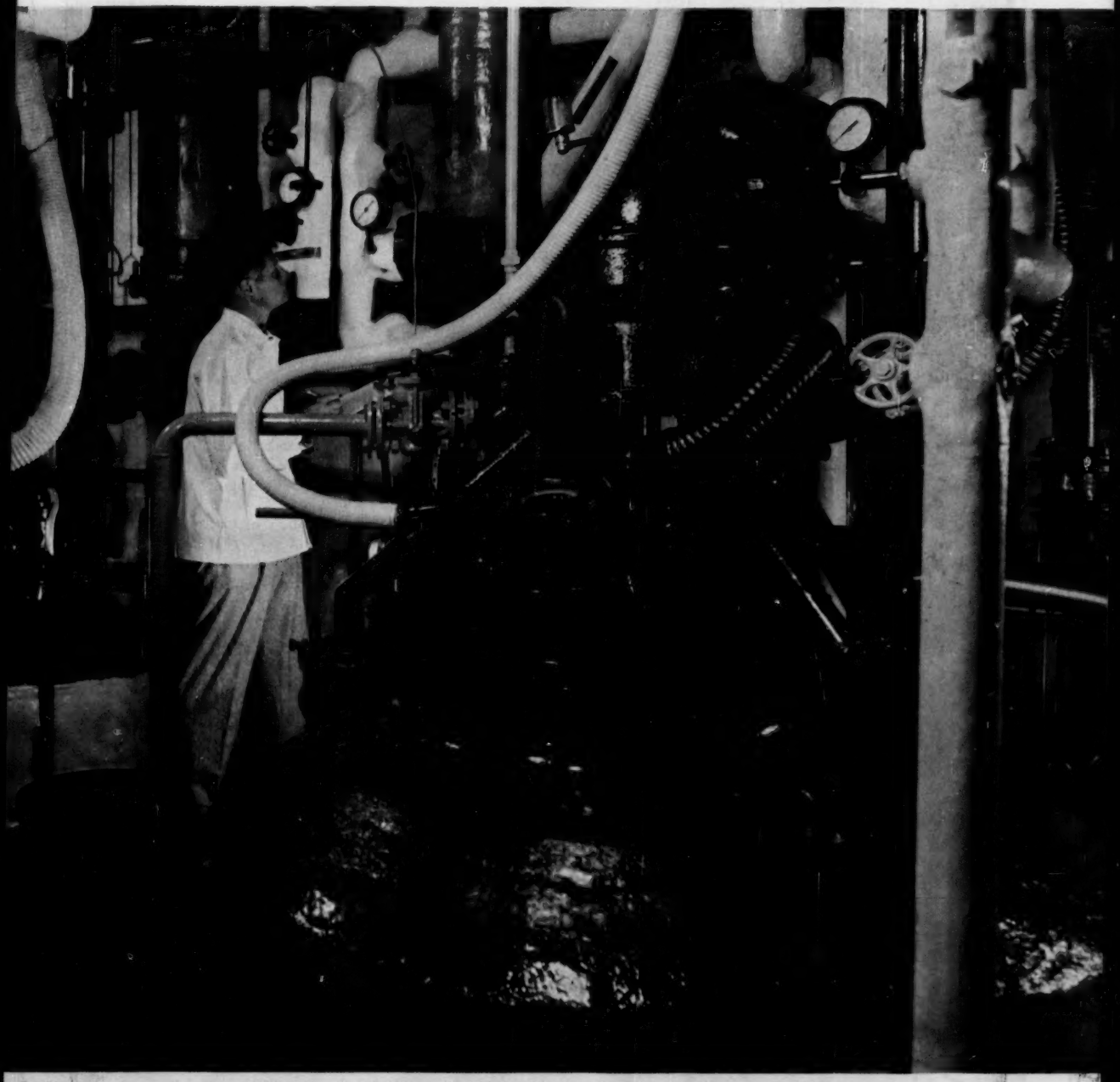
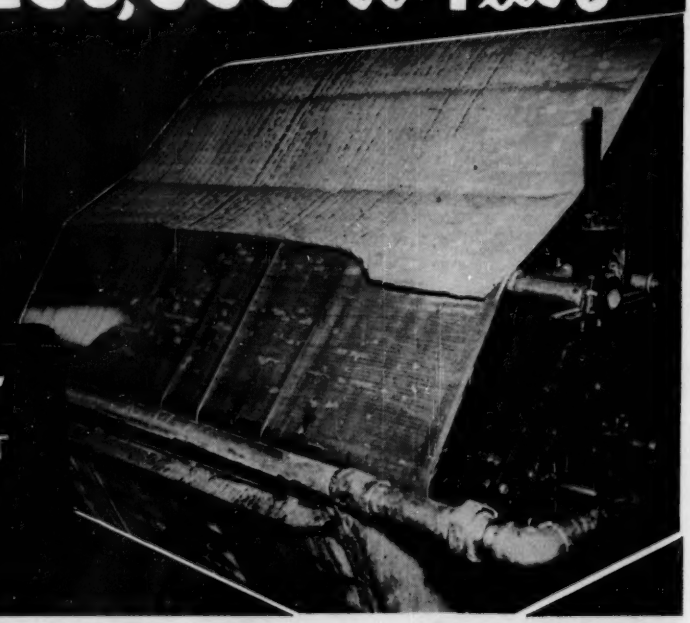


Agitated vessels: a critical look at film coefficients for heat transfer—p. 133

Engineering data enhance ion exchange's versatility as an important processing tool—p. 115

Cost equations define minimum investment for batch processing equipment—p. 121

Saves $200,000 a Year



EIMCOBELT
CONTINUOUS BELT
DRUM FILTER

A chemical processor was recovering gypsum by thickening followed by two stages of countercurrent washing on standard drum vacuum filters.

The filtration was not satisfactory. Excessive blinding of cloth filter media resulted in a daily loss of hundreds of pounds of valuable product.

When an EimcoBelt filter replaced the standard drum filter for the first filtration stage in this operation, it immediately overcame all blinding difficulties. Soluble losses were reduced to less than one-third of the average former loss experienced with the two conventional drum filters . . . resulting in savings of over $200,000 a year.

It soon became apparent that the EimcoBelt could handle the filtration load formerly handled by the two drum filters. Accordingly, the second stage drum was eliminated from the flow-sheet.

Freedom from blinding is one of several ways the new EimcoBelt filter is greatly extending the usefulness of vacuum filters.

EimcoBelt filter's unique new operating principle removes the filter medium from the drum every cycle, discharges the cake and washes the medium while it is away from the drum. A thoroughly cleaned medium is always returned to the drum.

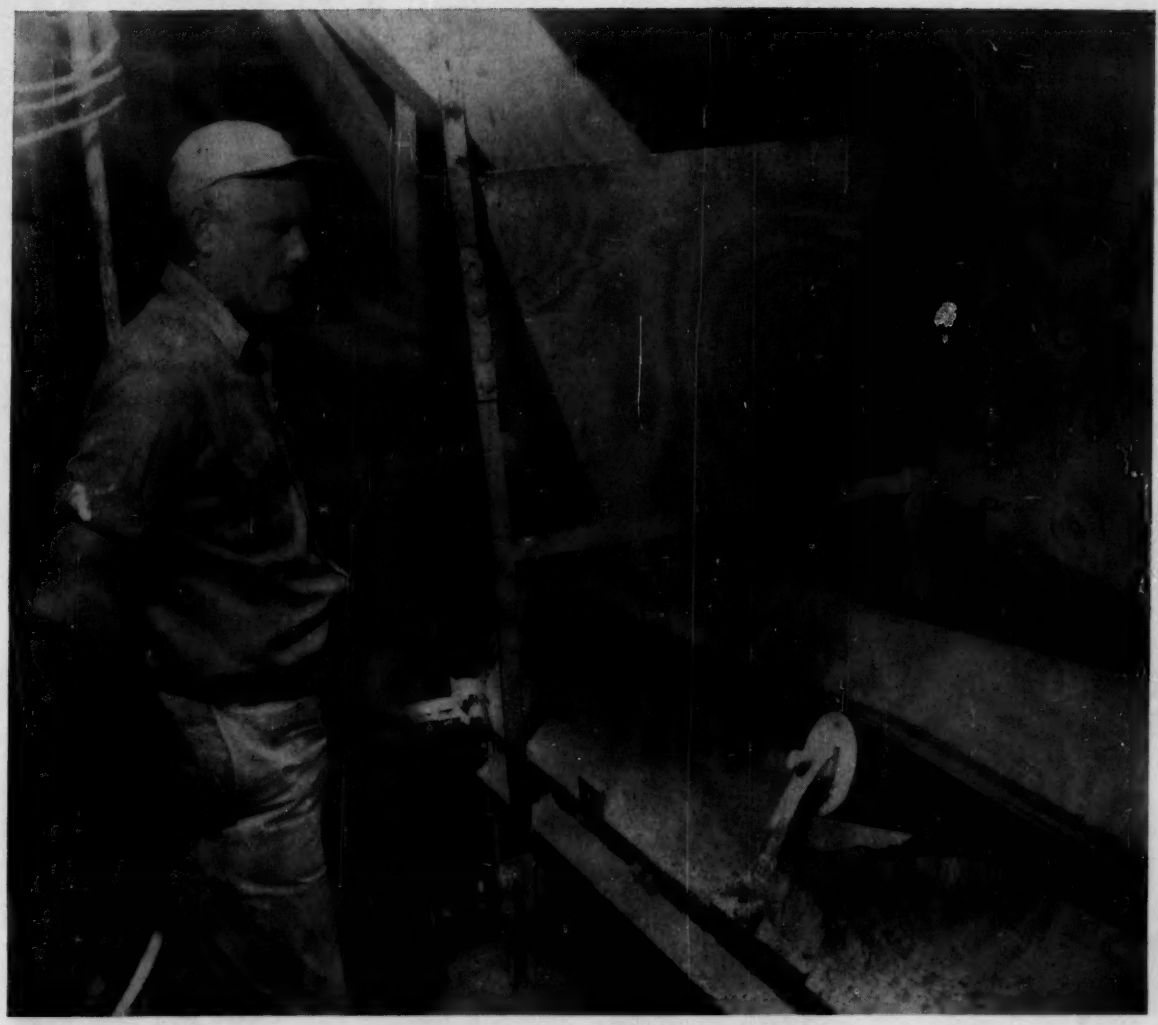
Ask the Eimco representative in your area how EimcoBelt filters can cut costs in your operations. And write Eimco Filter Division for Bulletin F-2053.

THE EIMCO CORPORATION

FILTER DIVISION
434 SOUTH 4TH WEST
SALT LAKE CITY, UTAH — U.S.A.

RESEARCH AND DEVELOPMENT CENTER
201 SO. HICKS ROAD, PALATINE, ILLINOIS

B-564



Rubber belt refuses to crack when the heat's on

Handles hot cargo that baked, hardened and broke other belts

THAT'S crushed limestone, still sizzling hot from the kiln, being taken to a discharge bin via conveyor belt. The conveyor operates 18 hours a day. But keeping it going used to be costly. The 200 degree heat baked rubber belts, soon they'd crack and break. Average belt life was only 5 or 6 months.

Then a B.F.Goodrich distributor recommended a new kind of conveyor belt, called Solarflex, designed specifically for handling hot materials. This belt is made of a special rubber that stays soft and pliable at temperatures that cause other belts to harden, crack and finally break down.

After 32 months on this job, the improved B.F.Goodrich hot-material belt shows no sign of wear, looks like it will be good for years to come. The limestone company has three other BFG Solarflex belts handling finished lime at even higher temperatures. And they, too, are standing the heat far better than any belts used previously.

When you call on a B.F.Goodrich distributor for help with a conveying problem, you can count on getting the kind of belting that will keep things in your plant moving, cut down on repairs, and give you more for your money in terms of long, useful service.

BFG distributors have full information on this hot-material belt. And, as factory-trained specialists in rubber products, they can answer questions about the many products B.F.Goodrich makes for industry. *B.F.Goodrich Industrial Products Co., Department M-910, Akron 18, Ohio.*

B.F.Goodrich

CONVEYOR BELTS

By 1970 you'll appreciate the lasting value of your 1960 investment in **Bird Continuous Solid Bowl Centrifugals**

Here's why we can say this and make it stick:

After 28 years a producer of southern clays retired their first Bird. They now have eleven in operation. The veteran unit installed in 1932 had been on the job 24 hours a day right up to this year.

Still turning out a fine salt of satisfactory dryness, after 18 years. Question: Should this Bird be repaired or replaced? Answer: Fix it up and it'll be good for many more years of faithful service.

Never opened up for five years. Used for dewatering the lime in a water softening plant, the user writes: "Since the unit has not been opened since it was installed five years ago, it may be time to have a look inside and see if anything needs to be done."

"Another Bird that has been running 24 hours a day since 1940 without mechanical attention." So runs the report from a leading producer of inorganic chemicals, and it continues, "Even so, the repairs are quite minor."

A billion pounds of salt from caustic is the record of a Bird that has been on the job twenty hours a day for the past 8400 days (23 years). Only routine annual check-ups have been required.

These are the kind of service records that can be achieved when corrosion or abrasion do not present serious problems. Even when these are factors, Birds outlast and outperform other separating equipment.

GET THE FACTS, by all means, on comparative dryness of solids, clarity of filtrates, capacity and cost per ton. **The Bird Research and Development Center** stands ready to supply the figures based on pilot-scale tests of your own feed slurries. But keep in mind that Birds are built for the long pull — an investment that brings returns year after year after year.

BIRD MACHINE COMPANY

SOUTH WALPOLE, MASSACHUSETTS

BUILDERS OF THE COMPLETE LINE OF SOLID-LIQUID SEPARATING EQUIPMENT

Operators of the **Bird Research and Development Center** for pilot-scale testing to determine the correct equipment for the job. Yours to use.

Application Engineering Offices:

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August 22, 1960

Chemical Engineering

CHEMICAL TECHNOLOGY FOR PROFIT-MINDED ENGINEERS

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- RESISTS CORROSION
- RESISTS THERMAL SHOCK
- EASILY FABRICATED
- HIGH MODERATING QUALITIES
- STRENGTH INCREASES WITH TEMPERATURE RISE

PRECISELY MACHINED GRAPHITE FOR THERMAL COLUMNS

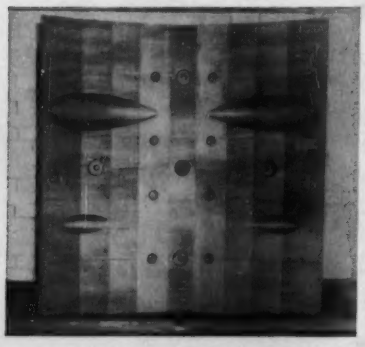
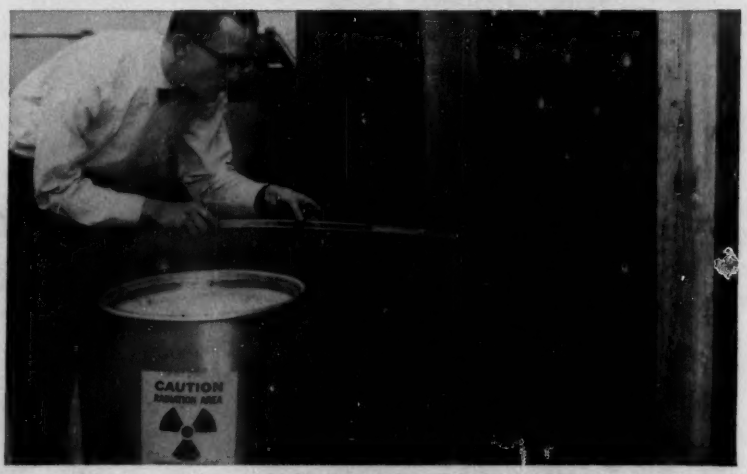


Photo shows inner wall of an 11 foot long graphite thermal column. Graphite was chosen for this installation because it is an excellent moderator of neutrons with low capture cross section.

This wall has 30 major blocks; the other 4 walls have 144 accurately machined blocks each. In all, 1300 precision machined graphite pieces are included in this thermal column. Close tolerances were held in machining each piece.

Many Universities are now using Graphite Moderated Training Reactors



Dr. E. F. Leonard, director of Laboratory Work for Columbia University, inserting a neutron source of plutonium-beryllium obtained from the Atomic Energy Commission.

A recently conducted survey shows that many universities throughout the country are using graphite exponential piles for training the sorely needed nuclear engineers of tomorrow. The survey also points out some of the advantages associated with graphite which are not found in other types of subcritical piles.

Graphite offers longer neutron diffusion (approximately 50 cm) and permits wider fuel rod spacing to assure accurate flux measurements. Also flux distortions are easily determined in graphite piles.

The structural and machineability features of graphite permit students to design and construct the pile. There are abundant experimental data and procedure history available on graphite (it's the oldest type of subcritical reactor) which permit more time for advanced experiments rather than basic fundamental experimentation.

A graphite pile also offers considerable flexibility. It is easy to change configuration, to introduce voids, to accurately position samples, and the pile can be operated as either a bare or reflected system.

Dr. T. J. Thompson, professor of Nuclear Engineering at M.I.T., removing a plutonium-beryllium neutron source from the subcritical nuclear reactor.

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highlights of this issue

HEAT TRANSFER IN AGITATED PROCESS VESSELS

What's the best method for predicting heat-transfer coefficients in agitated vessels? It depends on the kind of agitator used, writes Pfaudler chemical engineer Edward Ackley. His article (p. 133) critically reviews the literature in this near-virgin field, introduces new information from Pfaudler studies, comes up with recommended equations for vessels equipped with paddle, propeller, anchor or turbine agitators.

ETHYLENE COPES WITH GROWING COMPETITION

Polyethylene and vinyl chloride resins hold the key to ethylene's future growth, according to an Arthur D. Little survey (p. 66) of this important petrochemical. Today's trend towards more merchant production of ethylene is expected to continue, with supply and demand in "reasonable balance," predict market researchers Messing and Bradley.

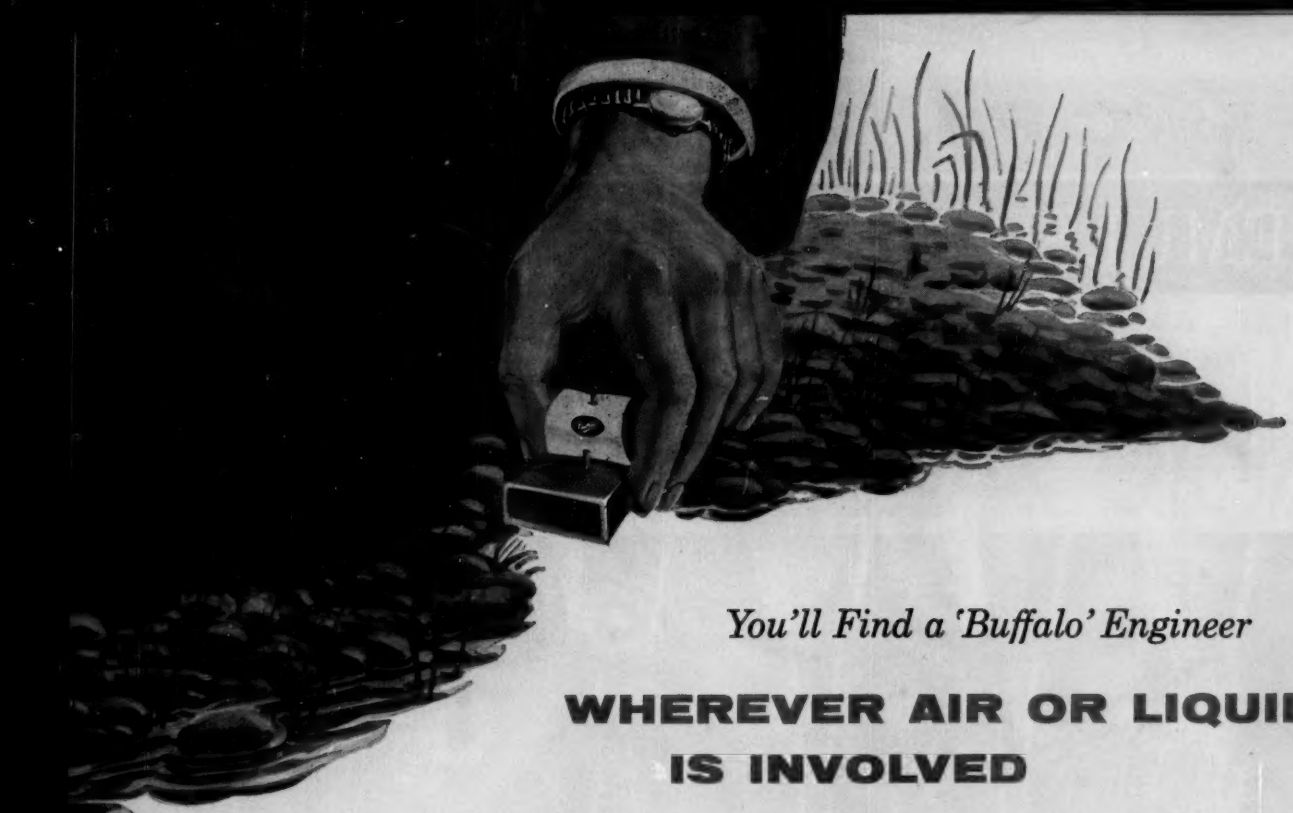
CONSIDER A JOB IN TECHNICAL SERVICE

Want to move into the sales end of the business, yet capitalize on your engineering training and experience? This issue's You & Your Job feature (p. 142) suggests you try technical service. Job satisfaction comes when "you see the results of your effort materialize into successful products."

MINIMIZE BATCH EQUIPMENT COST

In design of batch processes, the chemical engineer must balance many different factors in order to come up with the economic optimum. This article (p. 121) shows how, using three worked-out numerical examples. Method is based on the iterative solution of partial differential equations.

"Buffalo"



You'll Find a 'Buffalo' Engineer

WHEREVER AIR OR LIQUID IS INVOLVED

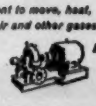
In *your* business . . . in every type of industry, commerce . . . from astronautics to zinc mining . . . you'll find 'Buffalo' Fans and Pumps performing vital air and liquid moving jobs. ■ From the start, our basic aims have been to build quality products . . . and to provide helpful service in putting these products to work for you. Our industry-wide reputation for 83 years best tells how faithful we have been to these principles. ■ Yet with all these years of experience, 'Buffalo' is still a young company . . . young in ideas . . . young in the enthusiastic pioneering of new and better ways of handling air or liquids. ■ Your 'Buffalo' Representative is as close as your phone. Call him next time you want to put air or liquid to work.

Buffalo Forge Company, Buffalo Pumps Div., and the Squier Corp. . . . **Buffalo, New York** . . . Canadian Blower and Forge Co., Ltd., and Canada Pumps, Ltd. . . . **Kitchener, Ontario.**

BUFFALO FORGE COMPANY

Buffalo air handling equipment to move, heat, cool, dehumidify and clean air and other gases.

Buffalo Machine Tools to drill, punch, shear, bend, slit, notch and cope for production or plant maintenance.



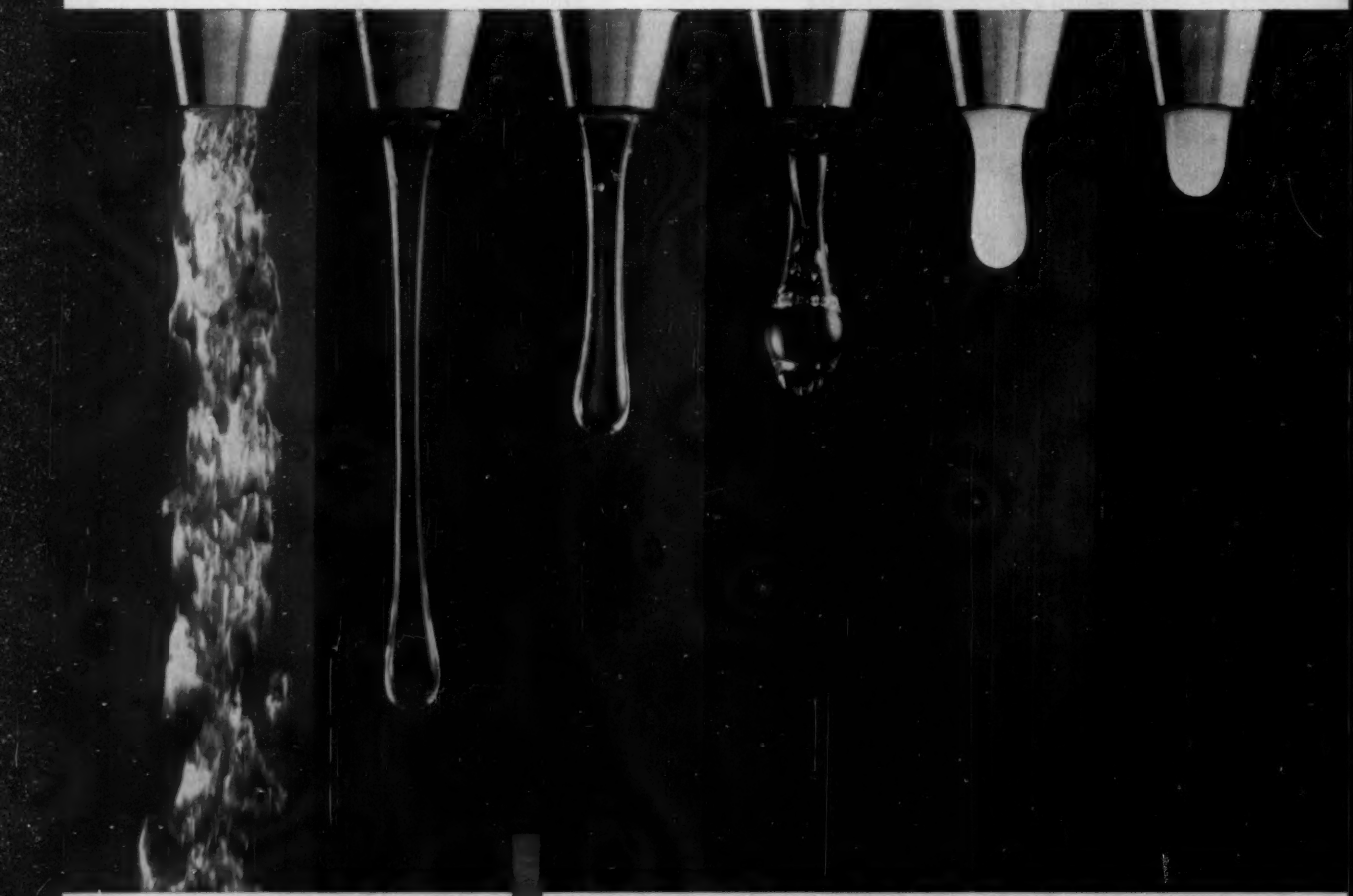
Buffalo Centrifugal Pumps to handle most liquids and slurries under a variety of conditions.

Squier machinery to process sugar cane, coffee and rice. Special processing machinery for chemicals.

Dow **C.P.I.** *file* **2**

EMULSIFICATION

EMULSIFIER INTERMEDIATES, by their almost unlimited number and properties, allow many emulsion formulations not possible with the usual commercial emulsifiers. Two such intermediates, polyglycols and alkanolamines, are outstanding for their ability to form excellent surfactants. Shown below are samples of polyglycols useful as surfactant intermediates and which are available in a virtually limitless range of viscosities.



For tailor-made surfactants, use these polyols from "the men that make the most of them"

PROPERTIES OF DOW POLYGLYCOLS

	description	viscosity range cks, 100°F.	approx. sol. g./100g. water at 25°C.
POLYETHYLENE GLYCOLS E200-E20,000*	viscous liquids to hard solids	20 to solid	∞
POLYPROPYLENE GLYCOLS P250-P4000*	viscous liquids	27.7 to 545	P250-400 ∞ P1200 2 P2000 up <0.1
POLYBUTYLENE GLYCOLS B500-B2000*	viscous liquids	58 to 258	all <0.1
POLYEPICHLOROHYDRIN 450-1150*	viscous liquids	387 to 3650	all <0.1
POLYSTYRENE GLYCOLS 500-750*	viscous liquids	10830 to 26000	all <0.1

*Numbers indicate average mol. wt.

ESTERIFICATION

WIDE SOLUBILITY, LOW TOXICITY MAKE POLYOLS EXCELLENT SURFACTANT INTERMEDIATES

Excellent ability as surfactant intermediates is shown by many of the Dow polyglycols. Because of the extremely wide choice of Dow compounds in this class, chemists can use them in surfactant production and be highly specific about low toxicity, low reactivity, specific solubilities in water and organics, and other properties.

Polyglycol intermediates used in the production of fatty-acid esters give controlled surface action useful in washing, softening, dyeing, and finishing. Being nonionic, the polyglycol fatty acid esters are important as suspending agents for dye pigments and as emulsifiers for oils and greases in fat liquoring. These esters find wide use as surfactants, dispersants, and wetting agents. Hydrophobic polyglycols can be converted to surface-active agents by sulfation, polyethylation, or reaction with other water-solubilizing intermediates.

Dow is basic in polyols. By having the widest line of starting oxides (ethylene, propylene, butylene, styrene, and epichlorohydrin), Dow has the ability to produce an unlimited number of new compounds. And by being a producer of all starting and intermediate materials, from hydrocarbon to oxide to glycol to polymer, Dow achieves a polyol quality which is a standard for the industry.

In addition to the availability of the polyglycols formed by adding a single oxide to a single glycol, Dow has developed a technology covering an unlimited number of variations using other starting materials. (See chart.)

SPECIFY NEEDED SURFACTANT PROPERTIES THROUGH DOW POLYOL VARIATIONS

SINGLE OXIDE + SINGLE GLYCOL

These are represented by all the standard Dow polyols described at the left. They are all available with complete technology.

ADDITION OF TWO OR MORE OXIDES TO A POLYOL

Problems that affect the "single" polyglycols above can often be overcome by multiple-oxide compounding. Example: high molecular weight polypropylene glycols have many useful properties but they are insoluble in water. Dow polyglycol 15-200, made from two oxides, is soluble in both water and organic solvents.

ADDING PROPYLENE AND ETHYLENE OXIDE TO MATERIALS OTHER THAN GLYCOLS—Starting materials such as propylene oxide or ethylene oxide reacted with phenols and fatty acids are used in making several surfactants valuable as emulsifiers, detergents, and wetting agents. The important property achieved is surface activity resulting from a proper balance of oil solubility and water solubility in the molecule.

ADDING COMBINATION OF OXIDES IN "BLOCKS"

Usually, when two or more oxides are used, they are added simultaneously and the resulting polyglycol represents a compromise between the properties of each oxide. However, adding oxides separately—by block addition—means that the properties of each may exist side by side. Many surfactant manufacturers use the block addition method to get the right hydrophilic-hydrophobic balance for surface activity.

Find out how "tailor-made" Dow polyols can solve problems or improve your existing products for you. Write to "The men that make the most of them."

SAPONIFICATION

MIXED ISOPROPANOLAMINE GIVES SOAP BETTER SOLVENCY AND COLOR STABILITY

Mixed isopropanolamine, a new member of the Dow alkanolamine family, has superior emulsification characteristics (better solvency and color stability) while retaining most of the desirable characteristics of other alkanolamines. Like triethanolamine, mixed IPA combines with free fatty acids to form soaps. These soaps find wide use as emulsifying agents for low-cost, easily prepared, stable emulsions. But here's a valuable difference. The soaps of mixed IPA are *completely* soluble in hydrocarbons such as naphtha, gasoline, and mineral oil in all proportions whereas TEA soaps are not. This property of mixed IPA yields solvent emulsions with greater stability.

Color stability is another outstanding characteristic of mixed IPA. Both the increased emulsion stability and the resistance to color change are important in products subject to long storage periods or extended shelf life. Mixed IPA may be substituted pound-for-pound for TEA since the equivalent weights of the two are approximately equal. Mixed IPA soaps are used as emulsifiers in dry-cleaning soaps, soluble textile oils, wax removers, metal cutting oils, cosmetics, emulsion paint, and in other products.

MIXED IPA SPECIFICATIONS		TYPICAL PROPERTIES	
Monoisopropanolamine	10—15%	Freezing Point	—30°C.*
Diisopropanolamine	40—50%	Pounds Per Gallon at 25°C.	8.37
Triisopropanolamine	40—50%	Viscosity at 25°C., centipoises	969
Apparent Equivalent Weight	137—143	Viscosity at 60°C., centipoises	44.6
Water, Maximum	0.5%	Flash Point (Cleve. Open Cup)	255°F.
APHA Color, Maximum	100	Fire Point (Cleve. Open Cup)	260°F.
Specific Grav. 20/20°C.	1.002—1.012	Odor	Slightly Ammoniacal

*Sets to a glassy solid below –30°C.

The Dow Chemical Company, Midland, Mich., Chemicals Merch. Dept. 426AK8-22.

☐ Choosing the Right Polyglycol ☐ 15 Series Polyglycols Booklet
☐ Polyethylene Glycols Booklet ☐ Polypropylene Glycols Booklet

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City_____ Zone____ State_____

DOW

THE DOW CHEMICAL COMPANY
Midland, Michigan

CORROSION meets its match in Alcoa aluminum conduit

Here's an electrical rigid conduit that you can install and forget.

Alcoa aluminum conduit solves most corrosion problems in and around chemical plants.

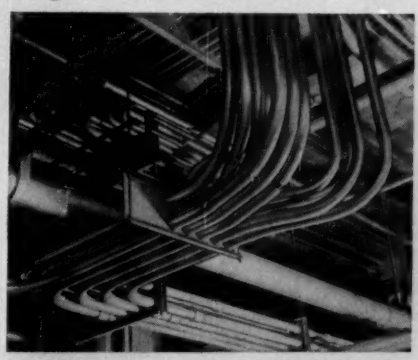
Aluminum protects itself Unlike other conduits, which require some kind of coating, aluminum forms its own protective film. This film forms naturally in the atmosphere and in the presence of oxidizing agents. Damaged spots are self-repairing—almost instantly! The natural oxide coating on aluminum takes the place of factory coatings on conventional conduits and only under unusual conditions is any other protection required.

Other advantages Corrosion resistance is just one good reason for selecting aluminum conduit. Its light weight (about ⅓ as much as steel) makes it easier to handle and install. Alcoa aluminum conduit is also nonmagnetic and non-sparking.

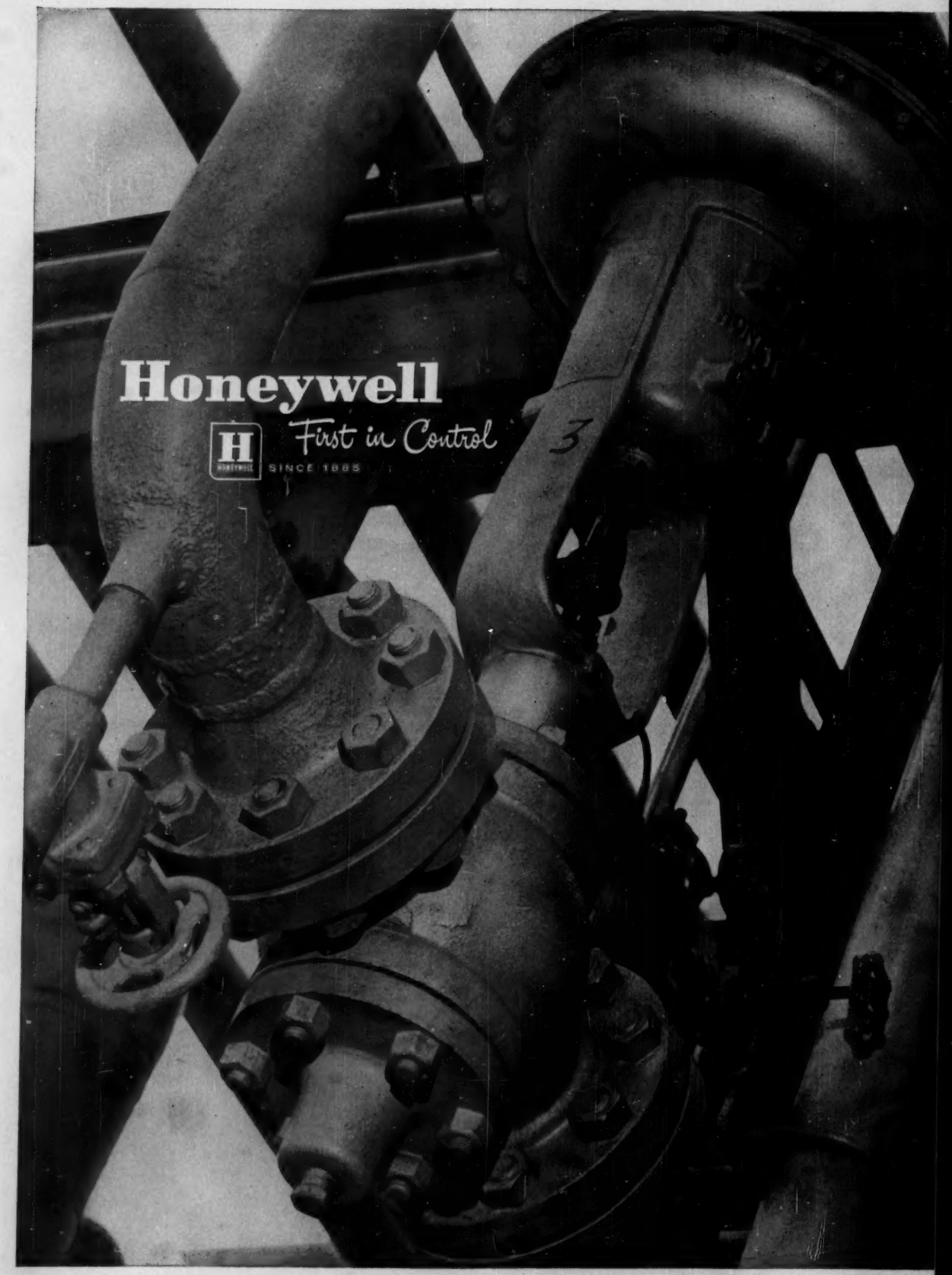
How about cost? Consider initial cost, savings in installation and maintenance, and service life. You'll see that Alcoa aluminum electrical rigid conduit stacks up as a sound investment.

More information For specifications, or answers to specific questions about the use of aluminum conduit in corrosive environments, contact one of our nearby representatives. Or write to Rome Cable Division of Alcoa, Dept. 22-80, Rome, New York.

ROME CABLE
DIVISION OF **ALCOA**



NO CORROSION despite moisture, chemicals and vapors in the basement of this sewage disposal plant in Cleveland. Installed in 1932, this Alcoa conduit still looks almost like new.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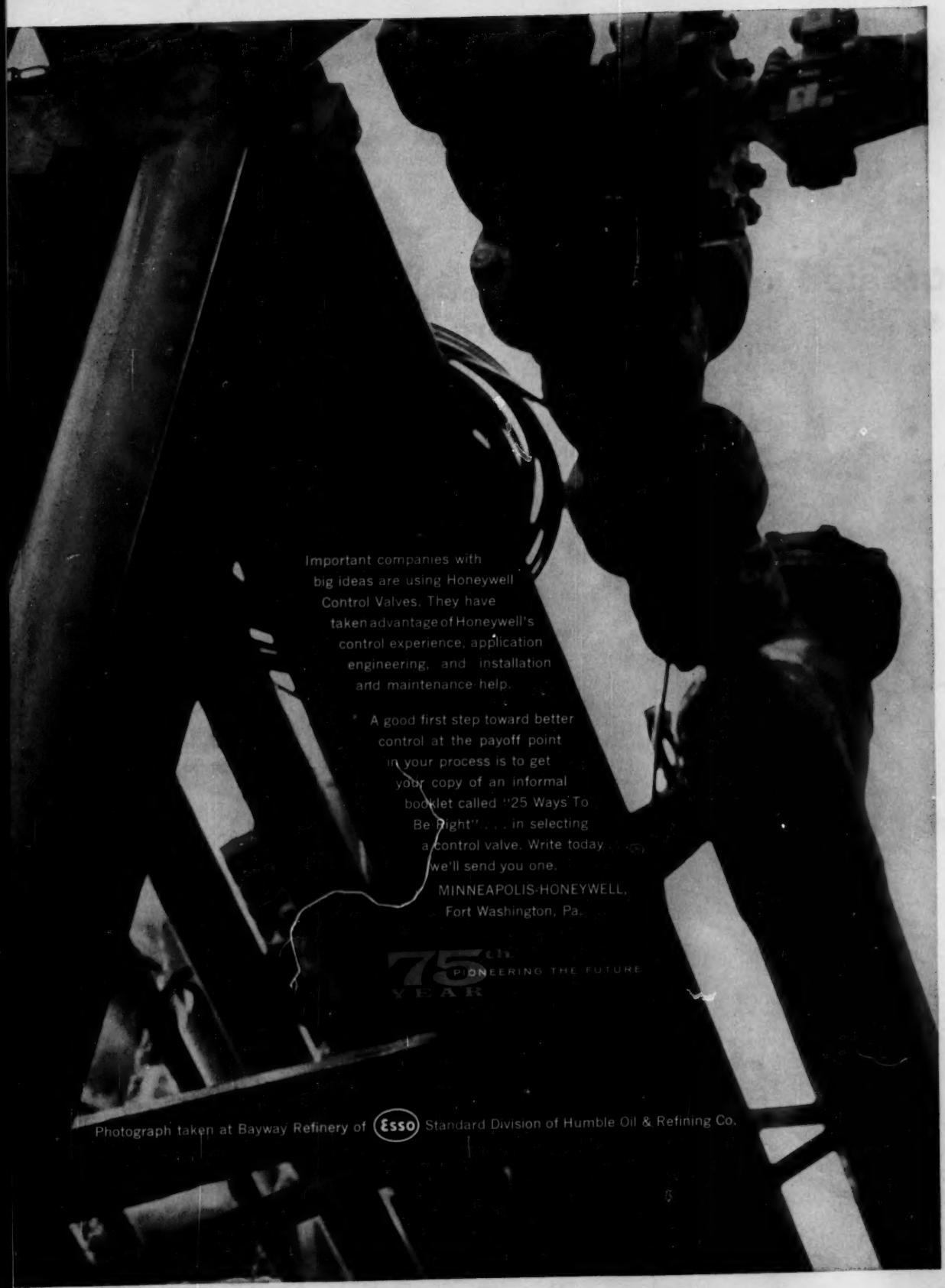
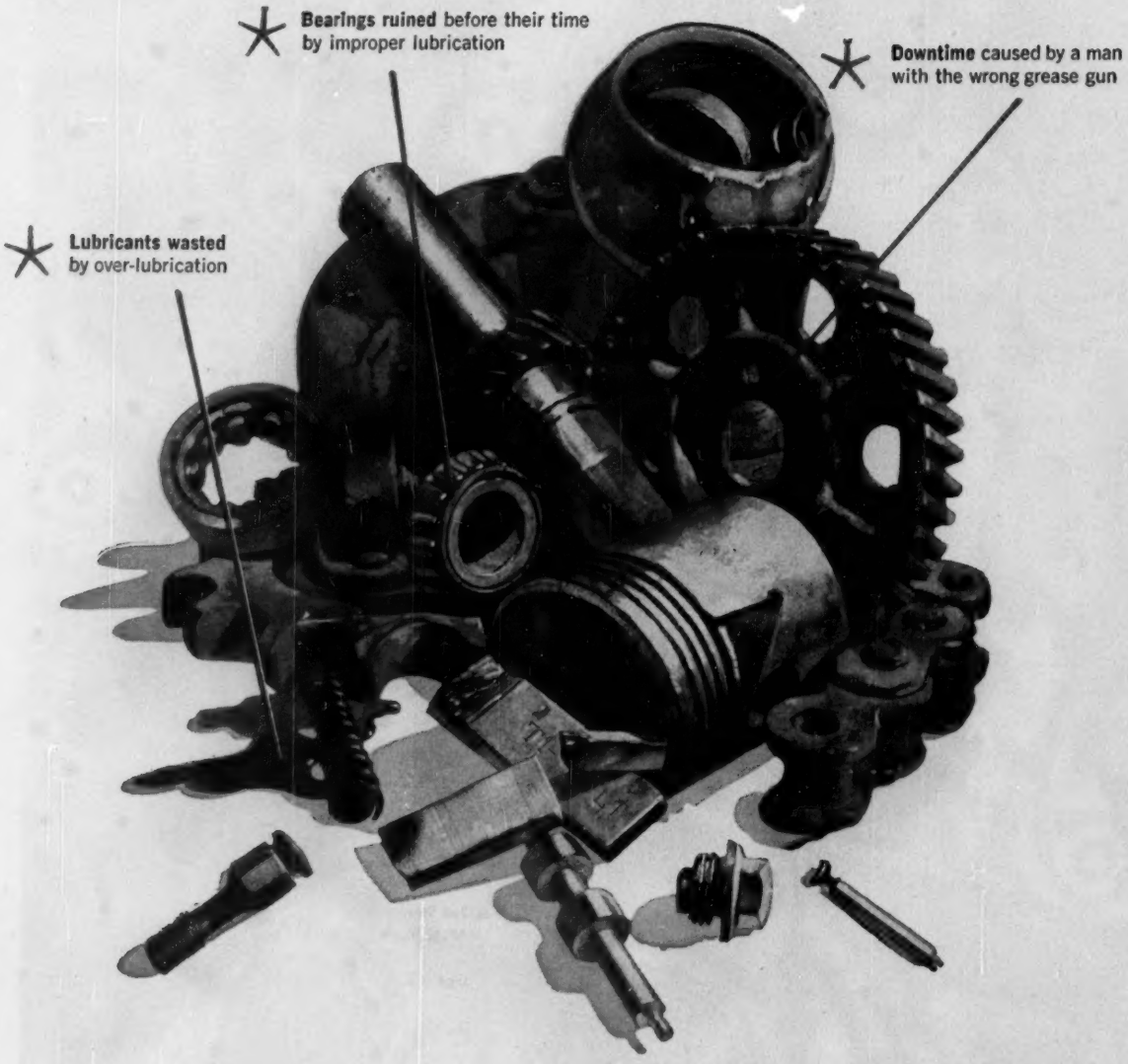
First in Control
SINCE 1885


Important companies with big ideas are using Honeywell Control Valves. They have taken advantage of Honeywell's control experience, application engineering, and installation and maintenance help.
A good first step toward better control at the payoff point in your process is to get your copy of an informal booklet called "25 Ways To Be Right" . . . in selecting a control valve. Write today . . . we'll send you one.
MINNEAPOLIS-HONEYWELL,
Fort Washington, Pa.
75th YEAR
PIONEERING THE FUTURE
Photograph taken at Bayway Refinery of Esso Standard Division of Humble Oil & Refining Co.

ANNOUNCING THE TEXACO "Stop Loss" Program

Created to starve a scrap pile at its source . . . and all it represents ✶


Bearings ruined before their time by improper lubrication
Downtime caused by a man with the wrong grease gun
Lubricants wasted by over-lubrication

LUBRICATION IS A MAJOR FACTOR IN COST CONTROL

Even though your plant is *already* an efficient operation, a Texaco "Stop Loss" Program can yield important savings in maintenance, production, purchasing and inventory.

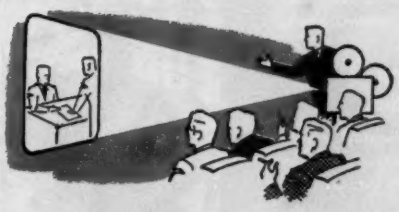
What it is; why it will work for you. The Texaco "Stop Loss" Program is a complete package specifically designed to modernize your lubrication practices—to keep pace with your updated production and marketing procedures. "Stop Loss" is based on our years of experience in organizing lubrication in the chemical industry.

If yours is an average chemical plant, the adoption of this program will actually show up on your profit sheet. That's because the savings from "Stop Loss" go *directly* into net profits.

Lubrication, far from being an expense item, is actually one of your most effective cost control tools!

HERE'S WHAT YOU NEED TO HELP STARVE YOUR SCRAP PILE

These components of the Texaco "Stop Loss" Program are available to interested plant groups:



1. New 20-minute sound-color film "Stop Loss with Organized Lubrication"—created to show the many opportunities for cost control through organized lubrication practices.

2. A Lubrication Control System that takes the guesswork out of lubrication scheduling. It costs almost nothing to install, yet can save as much as 15% of your maintenance costs.

3. A film "package" for various departments. This consists of educational films that cover the selection and application of greases, hydraulic oils, cuttings oils, etc.

4. Co-ordinated booklets on the film subjects plus many others that can be used as guides in specific areas.

We believe that a modern Texaco "Stop Loss" Program will produce a package of economies in your chemical plant.

MAKE YOUR RESERVATION TODAY
to see one of the year's most important management movies!

TEXACO
Throughout the United States
Canada • Latin America • West Africa

TEXACO INC., Dept. CE-CP-41
135 East 42nd Street
New York 17, N. Y.

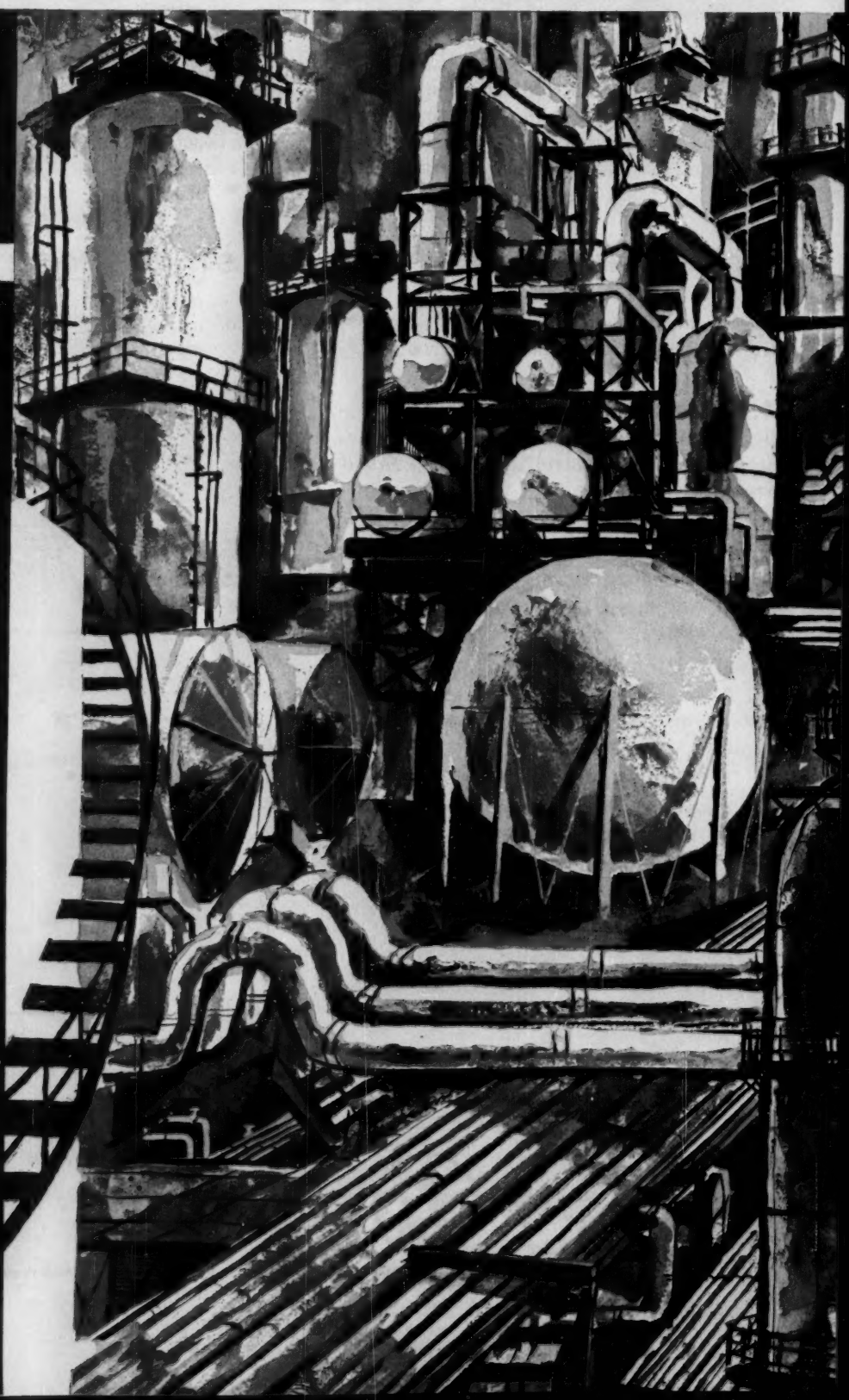
Please arrange a showing of "Stop Loss" at my plant.

Name_____

Title_____

(Please attach to your letterhead)

How General Electric PRODUCT INNOVATION



ADDED VALUES

QUALITY CONTROL

Quality control influences every G.E. operation, from order receipt to shipment.

PRODUCT INNOVATION

Product research and development is advanced in all 98 G.E. laboratories.

APPLICATION ENGINEERING

Customer-oriented application engineers assist you with systems integration.

ANALYTICAL ENGINEERING

The latest tools of process analysis are available for studies of your problems.

INSTALLATION AND SERVICE ENGINEERING

Expert on-site assistance gives you smoother installation and earlier start-up.

SYSTEM CO-ORDINATION

G.E.'s systems experience focuses the full Company capabilities on your order.

NATION-WIDE SERVICE SHOPS

More than 50 G.E. Service Shops offer you 'round-the-clock maintenance service.

PROMPT DELIVERY

Accurate delivery cycles put your new G.E. equipment to work for you—on time.

VALUE ANALYSIS

Value Analysis gives you optimum combination of product value and economy.

helps give the petroleum and chemical industries

PROCESS FLEXIBILITY

Recognizing your urgent needs for flexibility to meet fast-changing process requirements, General Electric is constantly developing more *versatile* products. General Electric investment in research and development, currently more than three times as much per sales dollar as the average for all industry, keeps G-E product versatility in step with your process requirements.

AN EXAMPLE OF GENERAL ELECTRIC PRODUCT INNOVATION is the new gyro-integrating true mass flowmeter. This versatile instrument continuously, accurately, and directly measures, *in pounds*, fluid streams over wide fluctuations in flow rate, density, pressure, temperature, and viscosity. The mass flowmeter eliminates the time-consuming—and sometimes erroneous—conversion of volume to weight. And *one* basic meter accurately measures a great number of industrial liquids and gases.

FOR MORE INFORMATION on G.E. product innovations that give your processes additional flexibility, call your local General Electric Apparatus Sales Office. General Electric Company, Schenectady 5, N. Y. 651-01

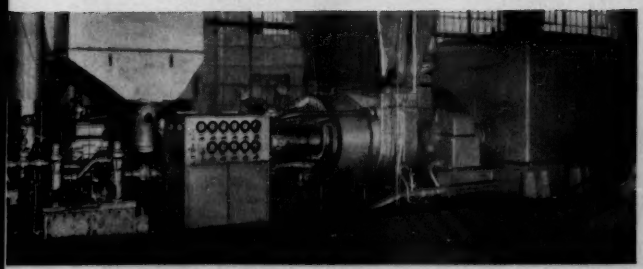
Progress Is Our Most Important Product

GENERAL ELECTRIC

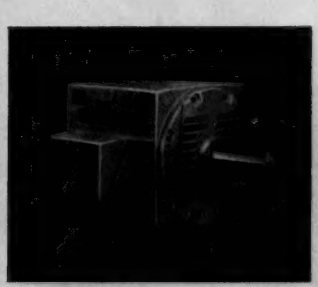
NEW GENERAL ELECTRIC true mass flowmeter handles many different process measurements:

LIQUEFIED GASES • INDUSTRIAL LIQUIDS

NATURAL GAS • REFINERY GAS • INDUSTRIAL GAS

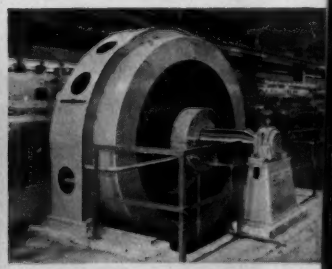


INDUSTRIAL GAS TURBINES, pioneered by General Electric in 1948, are continually being improved for simultaneous double duty: reliable shaft power and economical heat for process hot air or steam.



NEW CUSTOM '8000'* a-c motors are guarded against damage from moisture and chemicals by special Polyseal* insulation systems.

*Trade-mark of General Electric Company

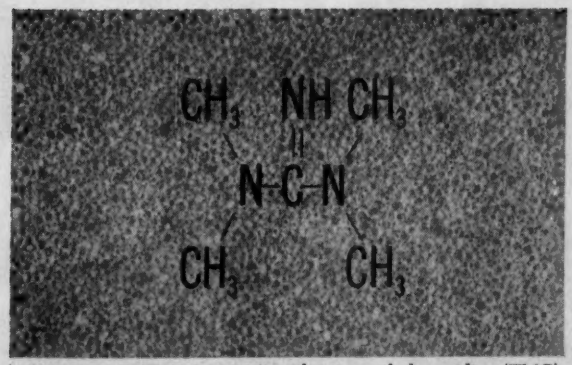


SYNCHRONOUS MOTORS with new and improved insulation systems operate reliably under many process conditions.

CYANAMID

Chemical Newsfront

"ANTI-SUNBURN LOTION" FOR PLASTICS provided by Cyanamid's new CYASORB® UV 314 ultraviolet light-absorbing chemical. *Left*—A month in the Arizona sunlight renders a sample of polyethylene brittle as an eggshell. *Right*—When protected with only 0.5% Cyasorb UV 314, the same plastic remains flexible even after *four* months in the same sunlight. Cyasorb UV 314 works same wonders for polypropylene. Fiber, sheet, film, and molded plastics can now be light-stabilized. **(Intermediates Department)**



BETTER RIGID URETHANE FOAMS—with tetramethylguanidine (TMG). Kinetic studies show TMG favorably active on price-performance basis in catalyzing primary and secondary hydroxyl reaction with NCO. Anticipated advantages include ease of handling, better cross-linking, minimum odor in final product, and possibly improved aging under high humidity. **(Market Development Department)**

NEW SALES APPEAL FOR ACRYLIC FIBERS! Five Cyanamid CALCOZINE* acrylic dyes have a history-making new look. They require no expensive retarders—no modifications that weaken light fastness. In addition they permit ease of application, simplified leveling and stripping, deep penetration and high spotting resistance. Versatile, they work well with true or modified acrylics on all types of dyeing equipment. *Trademark **(Dyes Department)**

ON THE CARPET! Cyanamid's ANTIOXIDANT 2246* forms only a small, but vital, part of the latex backing that locks carpet loops in place. It prevents oxidation, keeps rug coatings free of brittleness and cracking, and minimizes discoloration.

(Rubber Chemicals Department)

For further information on products in this advertisement, wire, phone—or mail this coupon to: CE-80

AMERICAN CYANAMID COMPANY
30 Rockefeller Plaza, New York 20, N. Y.

Please send me additional information on

- ☐ CYASORB UV 314 LIGHT ABSORBER
- ☐ TMG
- ☐ ANTIOXIDANT 2246
- ☐ CALCOZINE ACRYLIC DYE

Name_____

Company_____

Position or Title_____

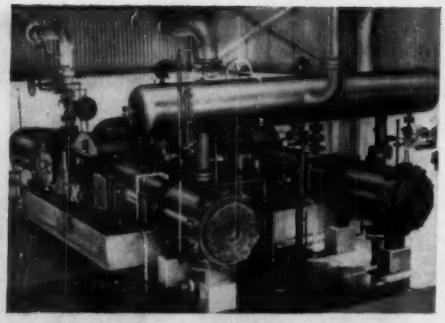
Address_____

City_____ Zone____ State_____

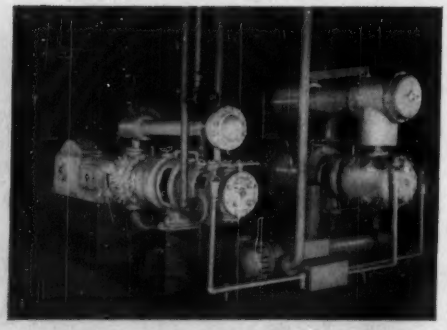
CYANAMID

AMERICAN CYANAMID COMPANY
30 ROCKEFELLER PLAZA, NEW YORK 20, N. Y.

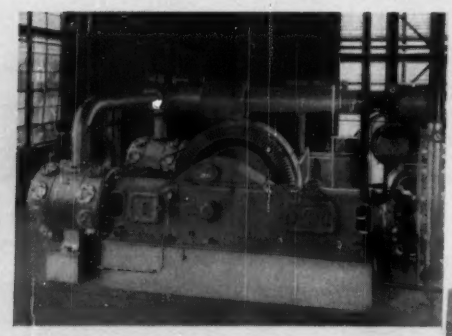
Horizontal



Single-stage, steam-driven hydrogen recycling compressor in a modern refinery.



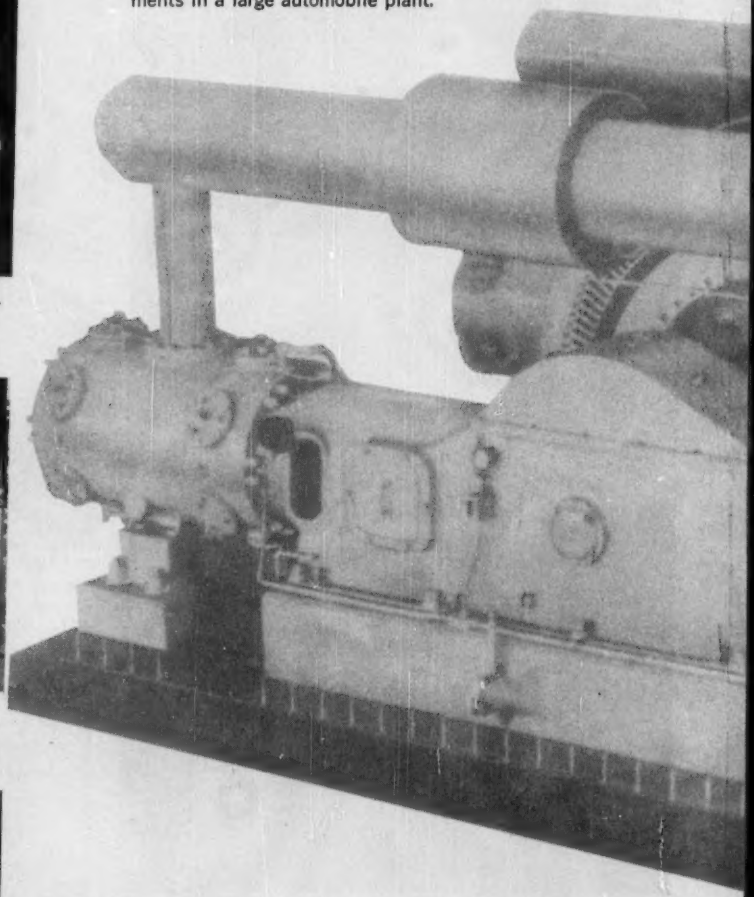
A 250 hp. four-stage compressor in an air separation process.



Three-stage, Class H-CE Compressor installed in a chemical plant.

Four 800 hp., O-CE Compressors serving an iron mine.

Four Class H-CE, four-corner Compressors supply all requirements in a large automobile plant.



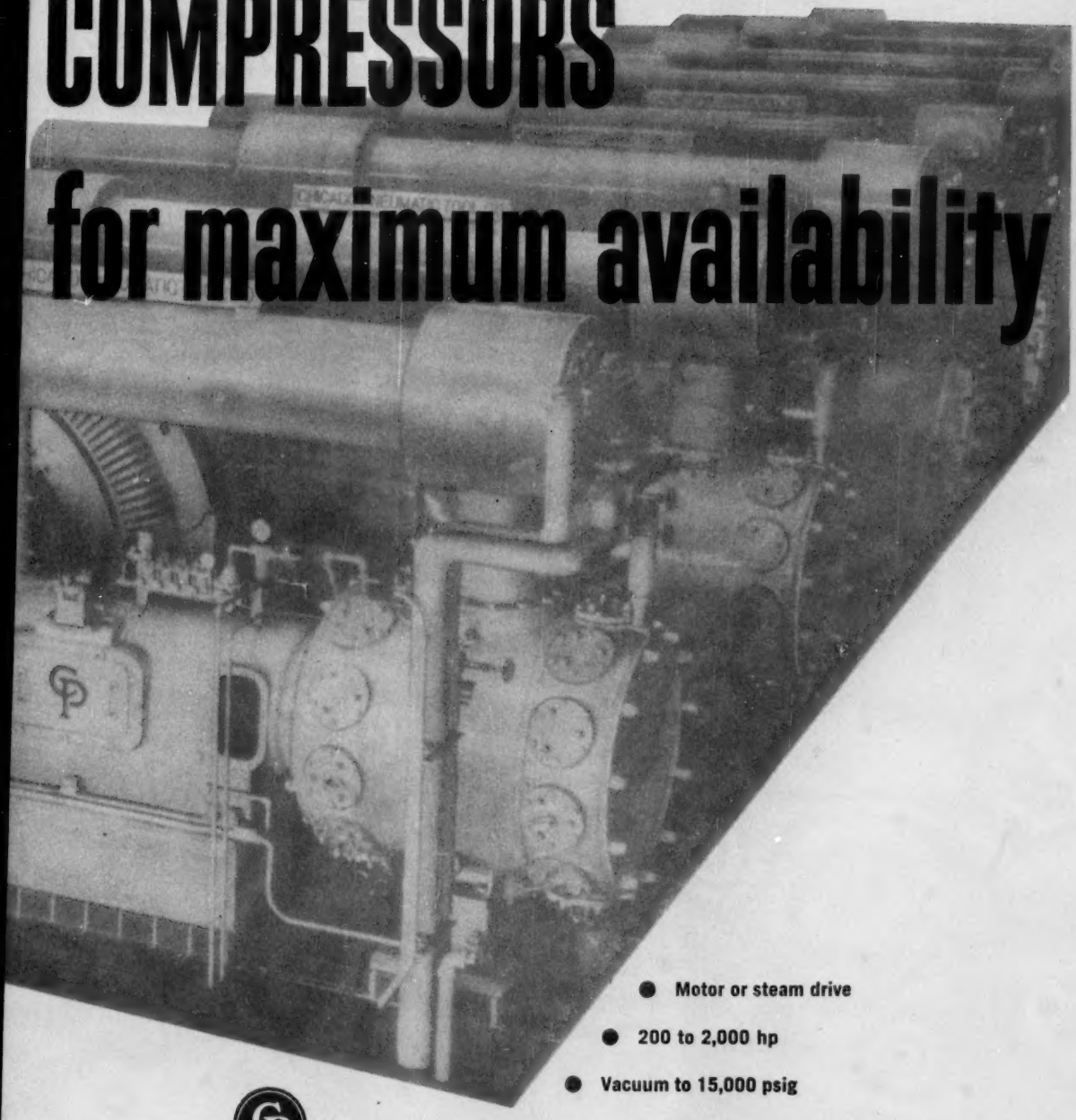
Chicago Pneumatic offers a wide variety of designs of compressors in sizes up to 5,000 horsepower and for pressures up to 15,000 psig.

Included are the Class O horizontal duplex and the Class H horizontal four-corner in addition to the Class FE balanced-opposed.

The horizontal duplex machines are preferred for many applications because of their low speeds, greater accessibility, greater flexibility of cylinder arrangements for many multi-stage installations, and lower maintenance cost.

For complete information, write: *Chicago Pneumatic Tool Company, 8 East 44th Street, New York 17, N.Y.*

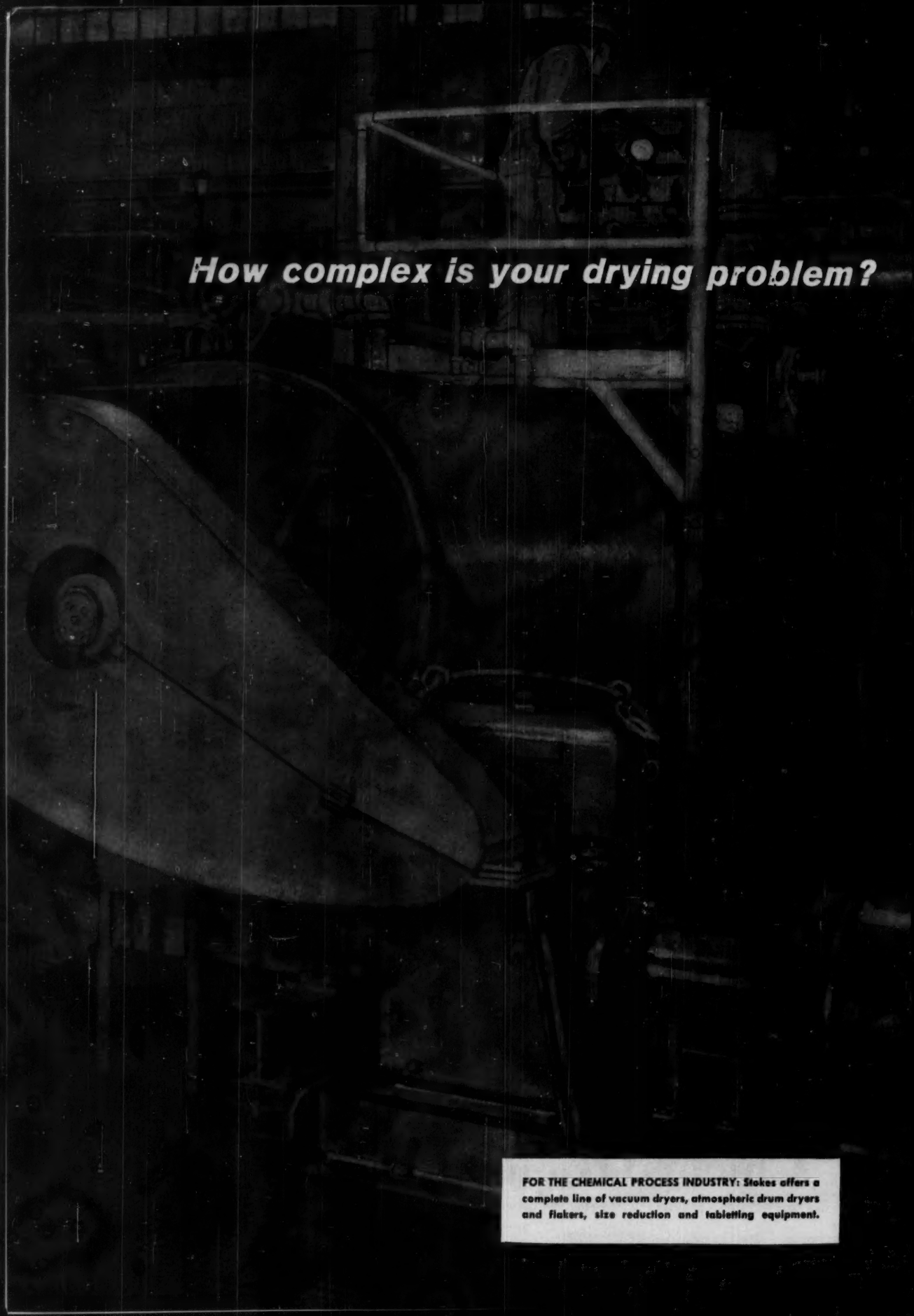
Duplex LOW SPEED COMPRESSORS for maximum availability



- Motor or steam drive
- 200 to 2,000 hp
- Vacuum to 15,000 psig

Chicago Pneumatic 8 East 44th Street, New York 17, N.Y.

AIR AND GAS COMPRESSORS • VACUUM PUMPS • PNEUMATIC AND ELECTRIC TOOLS • DIESEL ENGINES • ROCK DRILLS • HYDRAULIC TOOLS


How complex is your drying problem?
FOR THE CHEMICAL PROCESS INDUSTRY: Stokes offers a complete line of vacuum dryers, atmospheric drum dryers and flakers, size reduction and tabletting equipment.

LET STOKES UNIQUE VACUUM DRYING EXPERIENCE and EQUIPMENT WORK for YOU

Processing tonnage quantities of materials in an inadequate vacuum dryer can be time consuming and costly. That's why Stokes experienced vacuum engineers study each drying requirement individually . . . then design the drying system to meet your specific needs. Drying systems from —60°F to 400°F, and in capacities from a few pounds to several tons are available . . . along with application engineering, laboratory service and pilot plant operations. Stokes puts its 50 years of vacuum and processing experience to work on every drying problem . . . bringing you both money-saving and quality results. What's more, Stokes manufactures all its own pumps and accessories to assure you one-manufacturer responsibility in addition to unparalleled vacuum know-how.

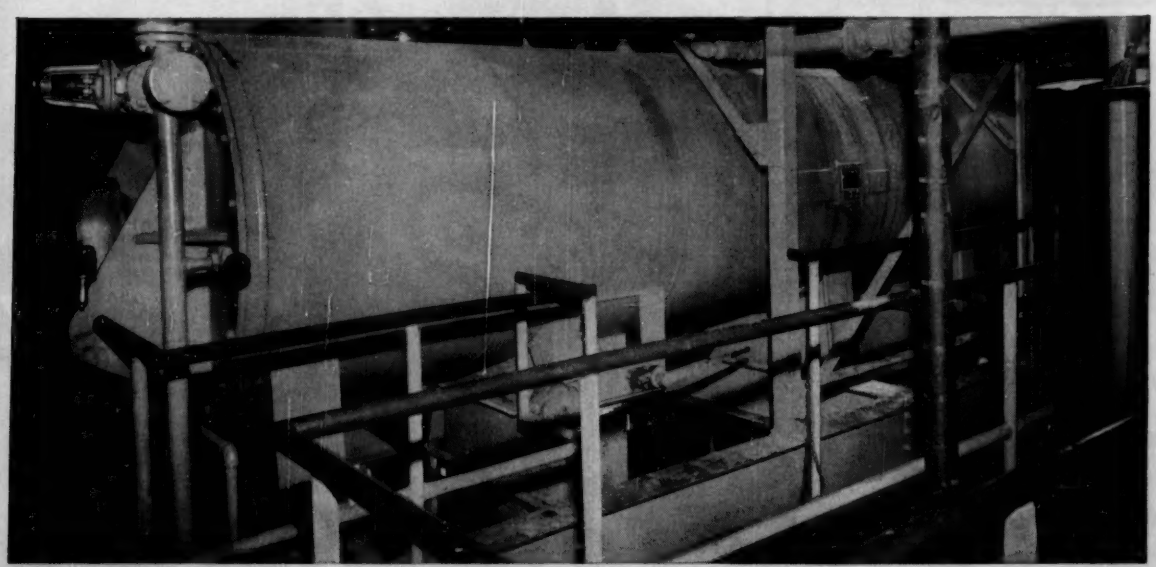
Stokes will work closely with your engineers to thoroughly explore the production problems . . . make recommendations on the basis of a practical knowledge of process operations . . . and confirm the recommended equipment by actual pilot plant production in the Stokes laboratory, if necessary.

Our representative in your area will initiate Stokes action to assure the best answer to your drying problem. Why not call him soon. Or if you prefer, write for new summary booklet on drying applications.

STOKES

Chemical Process Equipment Division

F. J. STOKES CORPORATION • 5500 Tabor Road • Philadelphia 20, Pennsylvania



Pictured above is one of two Stokes rotary vacuum dryers used to process Xanthates in the Welland plant of North American Cyanamid, Ltd. Continuous operation that means no maintenance shutdowns, process uniformity that means more pounds of salable product, and operating efficiencies that mean more profit are standard features of these Stokes rotary vacuum dryers.

Why Hunter Packing Company uses STANOIL Industrial Oil

Two reasons: (1) STANOIL is a superior oil. (2) Along with STANOIL, Hunter Packing receives experienced lubrication technical service.

A special antioxidant in STANOIL gives the oil resistance to *chemical* change. Deposits are minimized. The oil has a high viscosity index, is resistant to *temperature* change. It lubricates effectively at both high and low temperatures. Due to special refining techniques, STANOIL will not readily emulsify. A special additive minimizes foaming. STANOIL has a low pour point. It flows freely at low temperatures. A rust inhibitor in STANOIL "plates out" on metal surfaces.

W. P. "Sandy" Wehking, the Standard Oil man who calls on Hunter Packing Company, has plenty of experience in technical service work. He's been at it for 17 years. Sandy studied chemistry at Blackburn College. He has also completed the Standard Oil Sales Engineering School.

To get more information about STANOIL Industrial Oil and to obtain technical help on your lubrication problems, call the Standard Oil office near you in any of the 15 Midwest or Rocky Mountain states. Or write, **Standard Oil Company (Indiana), 910 South Michigan Avenue, Chicago 80, Illinois.**

Quick facts about **STANOIL Industrial Oil**

- Antioxidant gives oil resistance to chemical change, minimizes deposits.
- Inhibitor "plates out" on metal surfaces, prevents corrosion.
- Receives special refining to eliminate emulsion problems. Contains additive to minimize foaming.
- High viscosity index. Resists temperature change.

You expect more from **STANDARD** *and you get it!*

Temperature check. Frank Perason of Hunter Packing Company and Standard Oil lubrication specialist W. P. "Sandy" Wehking inspect one of four compressors in Hunter plant that uses STANOIL Industrial Oil.

MAKING NEW AMMONIA PLANTS

STILL BETTER INVESTMENTS

Recent developments by The M. W. Kellogg Company in steam reforming make the production of ammonia by this process more efficient, more economical to install and operate, and more adaptable to individual conditions than ever before.

IN GAS PREPARATION, Kellogg now can design a plant for any combination of waste heat recovery suitable to the situation, and can achieve heat balance in the plant if desired. High pressure and low pressure feed can be used as economics dictate. Feedstocks can include naphtha as well as natural and refinery gas.

IN GAS PURIFICATION, Kellogg now can offer the optimum combination of methods to accomplish each step, including MEA and hot carbonate to remove CO_2, and copper liquor and methanation to remove CO.

Throughout the entire installation—from furnaces to synthesis converters—Kellogg's improved steam reforming process offers today's ultimate in low-cost, high-yield ammonia plants.

Among the many ammonia plants engineered and/or erected by Kellogg throughout the world since 1944 is the 300 T/D installation for Solar Nitrogen Chemicals, Inc. at Lima, Ohio, shown above. M. W. Kellogg is now designing and will erect a second plant for Solar—at Joplin, Mo.

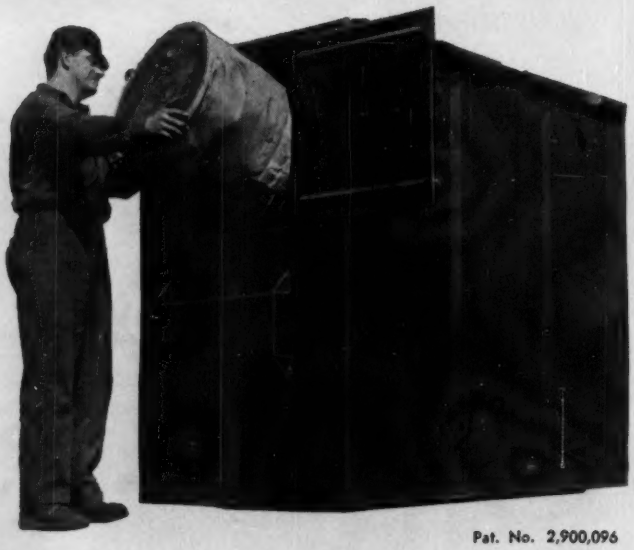
For detailed engineering and economic data on Kellogg's steam reforming process, write for new booklet.

THE M. W. KELLOGG COMPANY

711 Third Ave., New York 17. *A subsidiary of Pullman Incorporated*

Offices of other Kellogg companies are in
Toronto, London, Paris,
Rio de Janeiro, Caracas, Buenos Aires

How our small plant solved its waste disposal problem WITHOUT CAPITAL OUTLAY....



Pat. No. 2,900,096

DEMPSTER-DUMPMASTER Equipped Hauler Provides Containers and Service for Small Fee

Our small Midwestern manufacturing firm did not generate enough refuse to justify ownership of its own refuse disposal system. Yet, it was plagued by unsightly trash piles, fire hazards and scattered refuse in the plant yard.

Our plant engineer then heard of a DEMPSTER-DUMPMASTER equipped private hauler in the adjoining city. A survey revealed that two big-capacity refuse containers, placed one at each end of the plant, would handle the entire refuse accumulation.

The private hauler placed the containers, and a small monthly fee covered maintenance, labor, hauling and dumping refuse. No capital outlay was involved, disposal costs were reduced, and plant housekeeping was vastly improved.

In all major cities, private haulers who own DEMPSTER-DUMPMASTER equipment render fast, efficient, low-cost refuse storage and collection service. They place one or 100 containers at your service for a reasonable fee. A free brochure describes their service in detail.

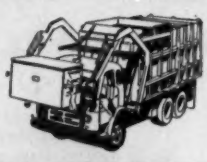
Free Brochure and Name of Nearest Private Hauler on Request

Dept. CE-8 DEMPSTER BROTHERS Knoxville 17, Tenn. Inc.

IN ALL LEADING CITIES FROM COAST TO COAST

DEMPSTER-DUMPSTER

DEMPSTER-DUMPMASTER

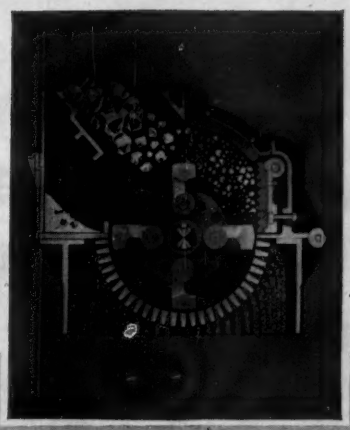


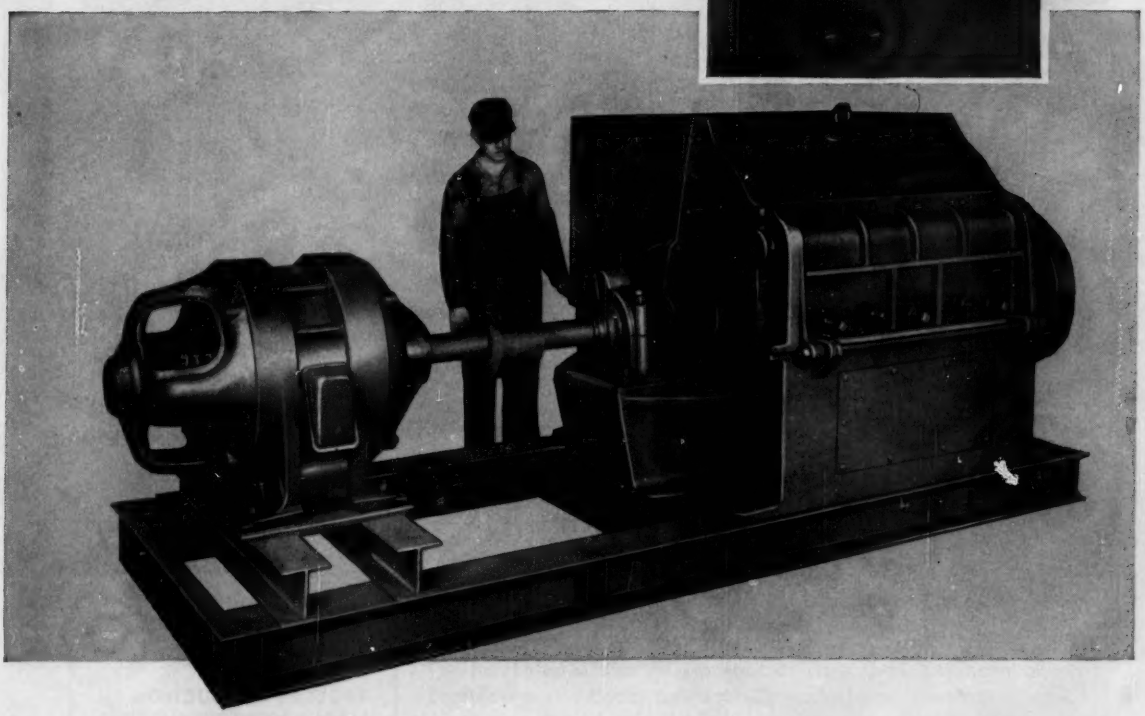
DEMPSTER COMPACTION TRAILER

DEMPSTER DUMPMASTER

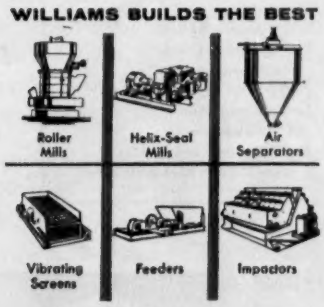
EQUIPPED PRIVATE HAULERS

Complete size reduction... from start to finished product... in a single Williams Hammer Mill





Cut costs as much as 50% on production... up to 75% on equipment



In all normal crushing operations, a Williams heavy duty hammer mill can take most material and, *in a single pass*, reduce it to finished size! Production economies alone, in labor, power, maintenance, as well as stepped up output of better quality and more uniform products, will *cut costs up to 50%*.

Savings in original installations, *as high as 75%*, can also be expected. By making primary and secondary crushers unnecessary, a Williams hammer mill will eliminate all extra conveyors, drives, other equipment, special foundations and additional housing.

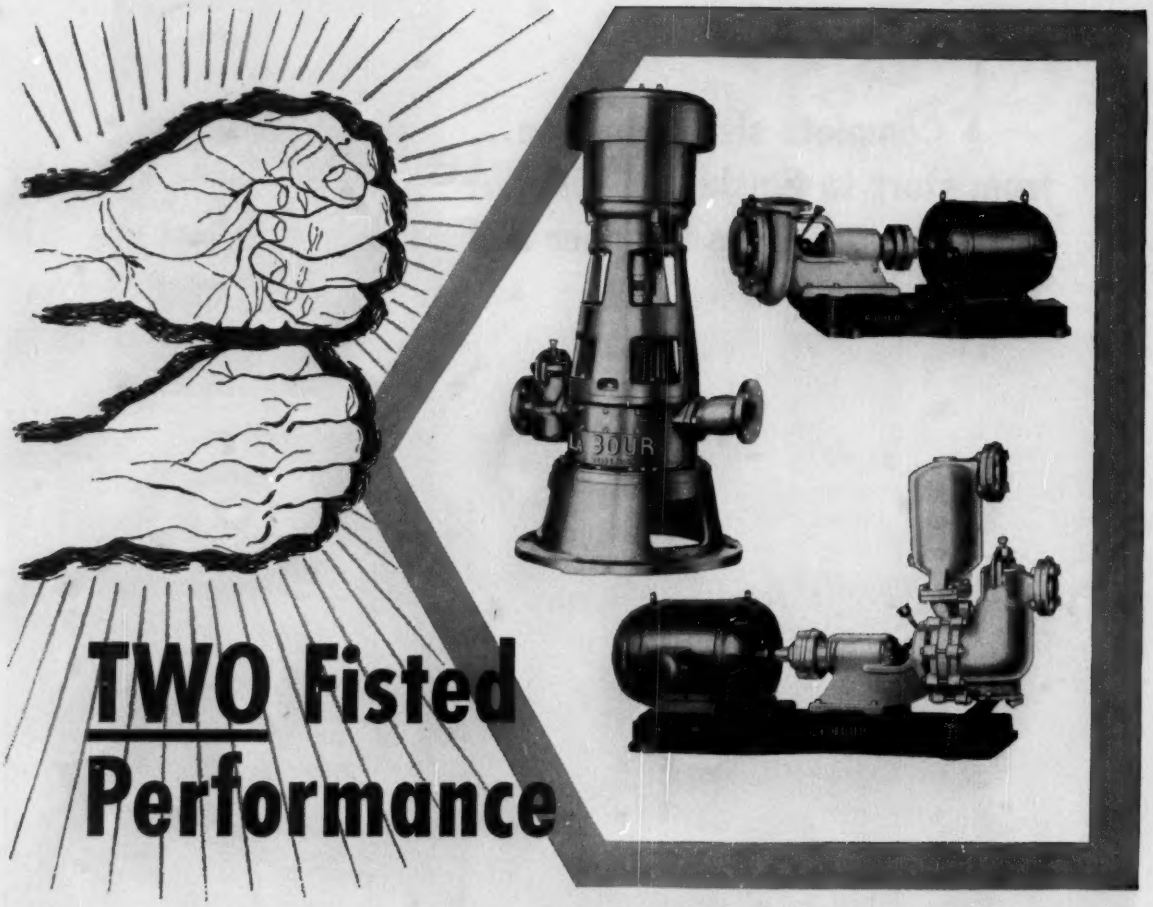
Williams hammer mills are built for daily rough and rugged service. Extra heavy manganese steel liners and breaker plates, oversize shafts, massive parts and reinforcements, all defy shock and wear, reduce downtime and replacements to nil.

If the cost price squeeze is one of your problems, get the facts about Williams hammer mills. *Write now for catalog.*

WILLIAMS
CRUSHERS GRINDERS SHREDDERS

Oldest and Largest Manufacturers of Hammer Mills in the World

PATENT CRUSHER & PULVERIZER CO.
2706 N. 9th St. St. Louis 6, Mo.



In pumping chemicals, maximum service satisfaction is dependent on *two* factors. Design and construction quality constitute one factor; the other is the accuracy of the foundry in meeting metallurgical specifications for corrosion resistance.

Because LaBour pumps embody such important and exclusive features of design it is perhaps easy to overlook the fact that LaBour foundries employ equipment and techniques second to none for precise control of alloy composition and grain structure.

That's why, when you buy LaBour, you get *two*-fisted performance assurance. Top ability to resist corrosion *and* top ability to move liquids economically and dependably are combined in these pumps. Ask for Bulletin B-lb.

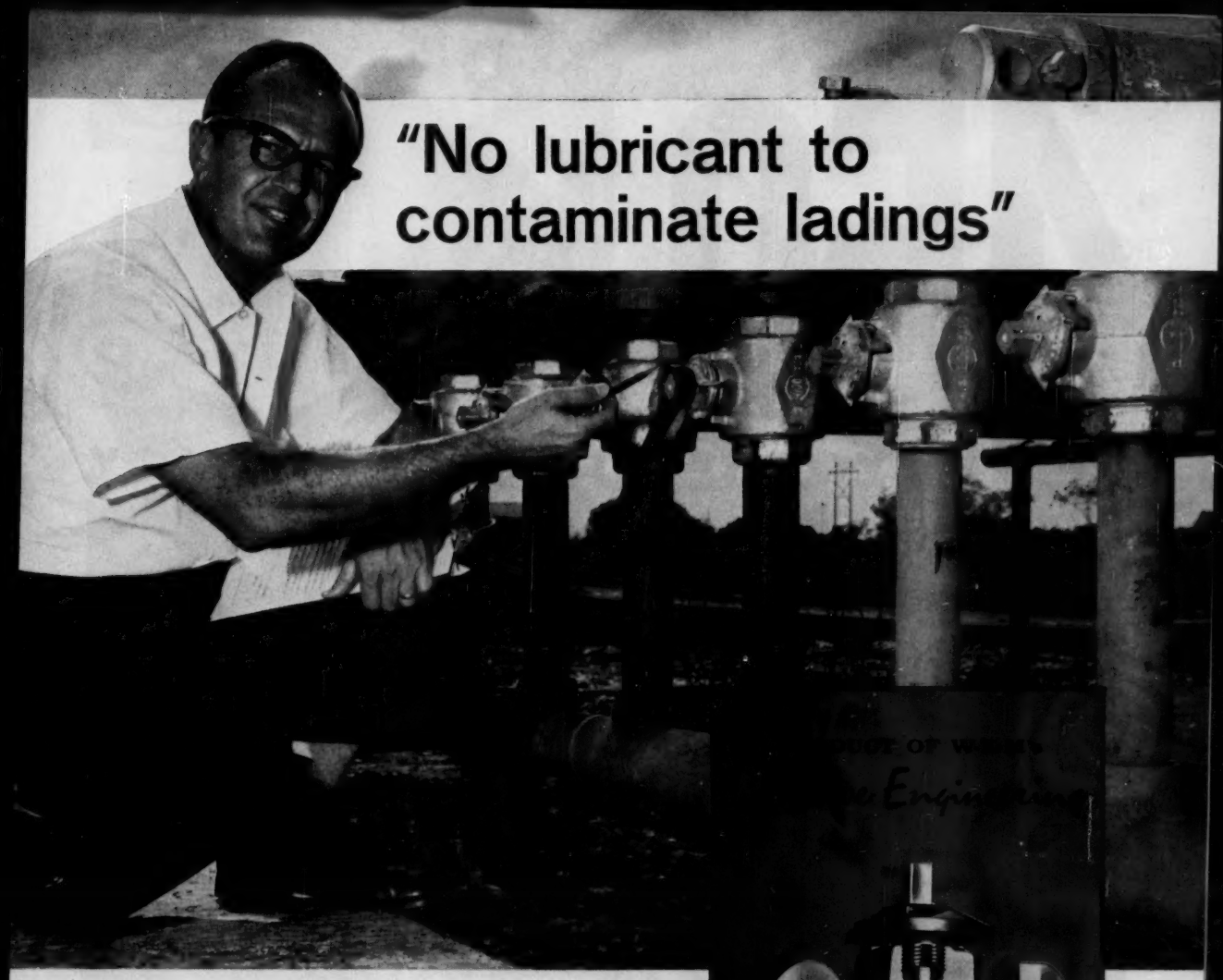
REGULAR PRODUCTION IN LaBOUR FOUNDRIES INCLUDES THESE ALLOYS:

- Electric Furnace Cast Iron
- Bronze
- Lead
- Aluminum
- R-55 (Chrome-Nickel)
- Y-17 (Chrome-Nickel-Molybdenum)
- Y-30 (Nickel-Molybdenum)
- 149 Stainless Steel
- 304 Stainless Steel
- 316 Stainless Steel
- Elcomet K (High Nickel Stainless)

ORIGINAL MANUFACTURERS OF THE SELF PRIMING CENTRIFUGAL PUMP

LABOUR

THE LaBOUR COMPANY, INC. • ELKHART, INDIANA, U. S. A.



"No lubricant to contaminate ladings"

acf® non-lubricated Ball Valves

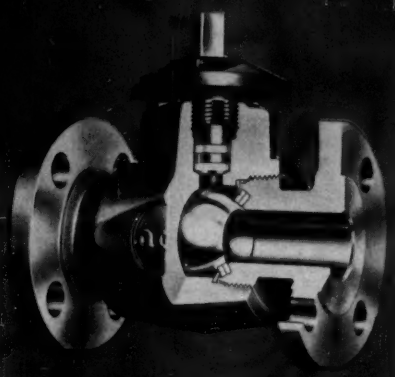
ACF Ball Valves are specially designed for ladings that require absolute purity. There is no lubricant, no possibility of contamination. The chrome-plated ball is suspended between Teflon seats under compression for leakproof sealing.

A quick quarter-turn operates this rugged valve. Specify it. You'll get efficient, economical performance. *Available at leading supply stores everywhere.*

Service-proved for 5½ years with such ladings as: gasoline • alkalis • liquefied petroleum gases • acetone • synthetic fuels • paint solvents • toluol • alcohol.

WRITE FOR CATALOG 1000

DIVISION OF acf INDUSTRIES
INCORPORATED
P. O. BOX 2117, HOUSTON, TEXAS



ACF non-lubricated Ball Valves feature full bore conduits, Teflon stem gaskets and seats that are sealed from the lading flow.

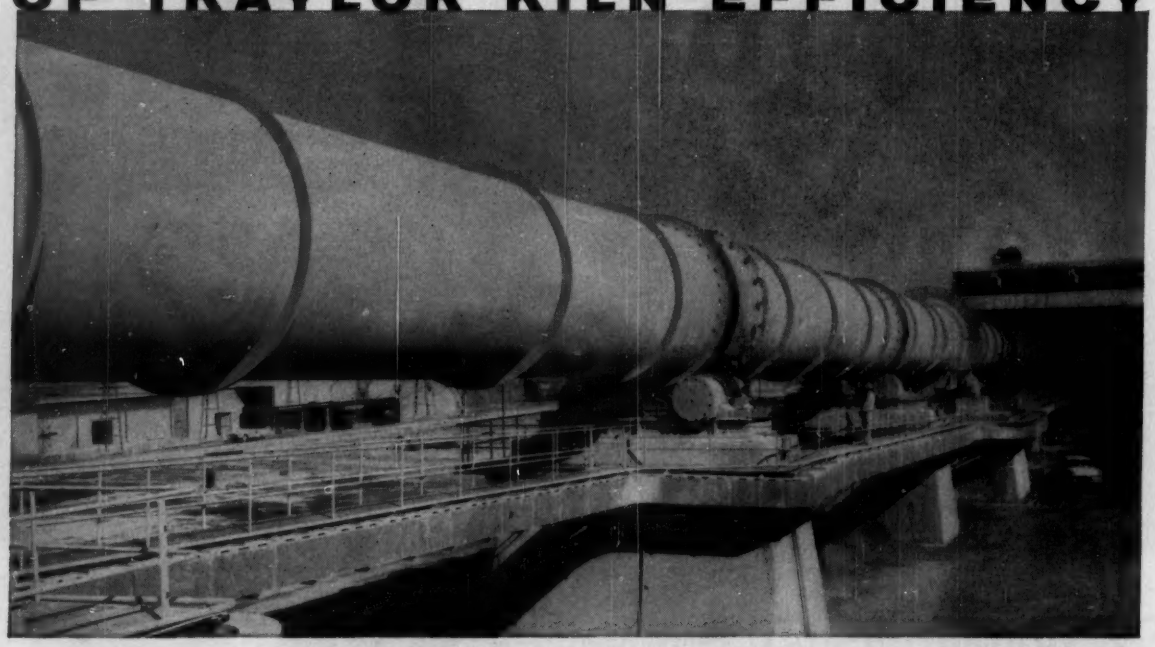
Working Pressures: In carbon steel with ASA ratings of 150 and 300, and a few sizes in ASA 600; in semi-steel with 200 and 400 pound ratings.

Sizes: ½" through 6".

5911-R2

450 FEET

OF TRAYLOR KILN EFFICIENCY



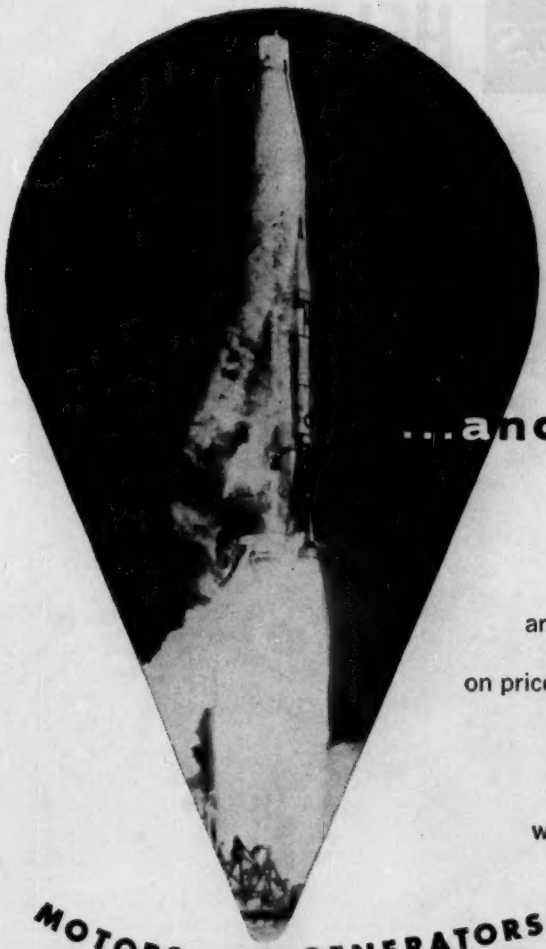
Shown above is one of two 12′ x 450′ Traylor rotary kilns designed and built to meet the requirements of the Standard Lime and Cement Company, Martinsburg, West Virginia. Both are wet process kilns driven by dual drives with forged steel riding rings and forged steel supports. These kilns feature the Traylor-designed chain systems and dust return scoops. They are fed by a Traylor slurry feeder.

Write today outlining your kiln requirements and let our engineers make recommendations . . . or write for Bulletin No. 1115.

TRAYLOR ENGINEERING & MANUFACTURING
DIVISION OF FULLER COMPANY
1551 MILL ST., ALLENTOWN, PA.

Sales Offices: New York — Chicago — San Francisco
Canadian Mfr.: Canadian Vickers, Ltd., Montreal, P.Q.

TKA-8



ME*

...and the mighty ATLAS!

The 40,000 integral parts of the world famous ICBM Atlas are monitored by Precise Power Supply Systems designed and manufactured by ME*. The selection of ME* over competitive companies was made, not on price, but on the thorough and exacting technical proposal submitted by ME* "Injun-eers". Our pride in this project is natural. Of more importance to you should be the "rolled sleeves" attitude and enviable "know-how" with which we face each challenging problem.

MOTORS and GENERATORS . . . that's our business!

Your next project should include Marathon Electric specifications. Let us prove what ME* Can Do . . . for you!

This data and specification file on Marathon Electric Motors and Generators is now available for your ready reference use. May we mail you your free copy now?

* Marathon Electric MANUFACTURING CORPORATION

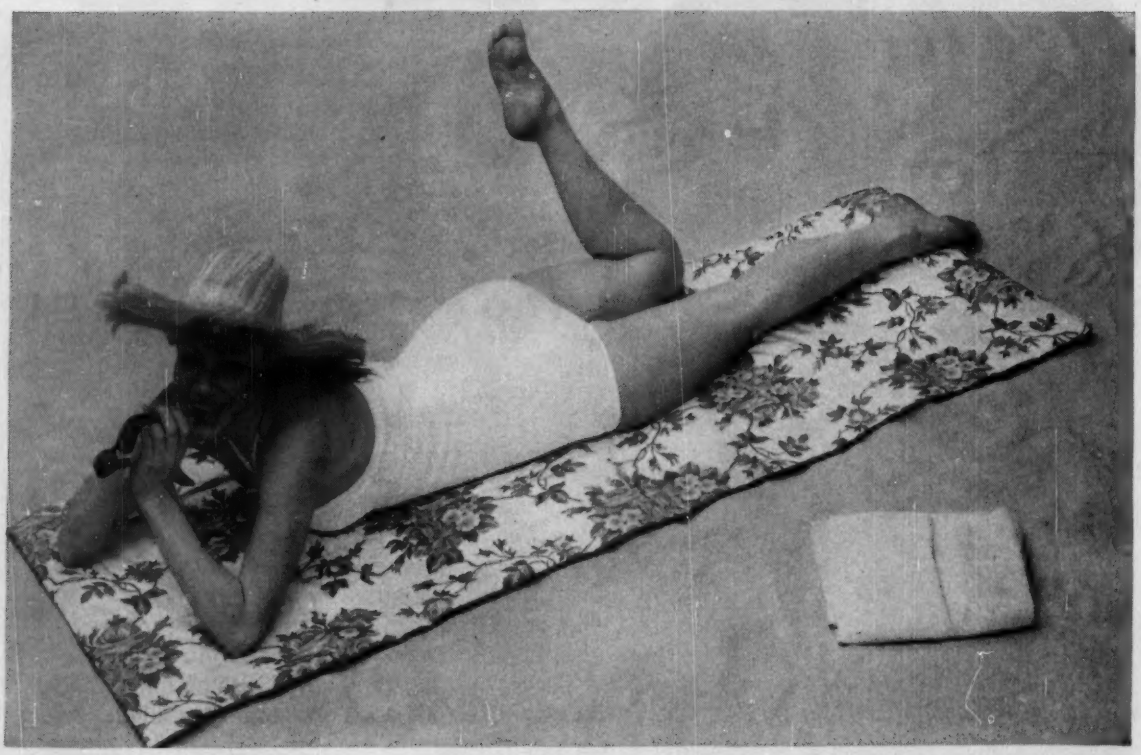
Home Office and Factory at Wausau, Wisconsin

Factories at Erie, Pa., and Eastville, Illinois

Offices in Principal Cities

MOTORS

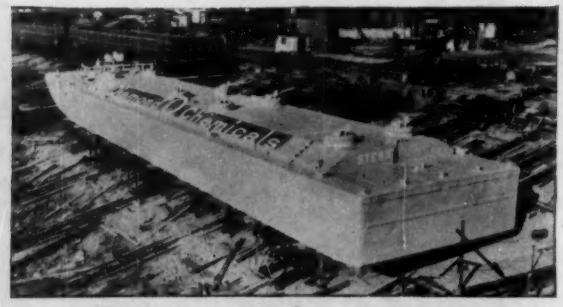
HOW *HERCULES* HELPS...



ON THE BEACH—Fun in the sun can easily become a nuisance when insect pests attack. But there's no problem when you use this beach roll made by the Julee Manufacturing Corp. The roll is impregnated with Metadelphene* Hercules diethyltoluamide—the most effective insect repellent yet devised. That's why Metadelphene has become the leading choice for all types of repellents—including lotions, sprays, creams, and roll-ons.

**Hercules trademark*

KEEP A BARGE "SHIPSHAPE"—Paints based on Parlon®, chlorinated natural rubber, were specified during the construction of this modern chemical carrying barge. Diamond Alkali Company found that Parlon, made by Hercules, is resistant to chemical corrosion and salt spray, and easy to apply and easy to maintain.



MAKE BETTER TUBING—This 33-foot length of Spiralloy® filament-wound, resin-bonded glass fiber is made by Young Development Division of Hercules. It weighs only 65½ pounds. It's flexible but won't dent, and most important of all, Spiralloy is lighter than aluminum and stronger than steel, an amazing strength-to-weight ratio.

HERCULES POWDER COMPANY
INCORPORATED
900 Market Street, Wilmington 99, Delaware

060-7

CHEMICAL MATERIALS FOR INDUSTRY

HERCULES

WOLVERINE TRUFIN®

the integral finned tube

interchangeable with plain condenser tube (Type S/T only)

easily fabricated—available in U-bends

one-piece construction

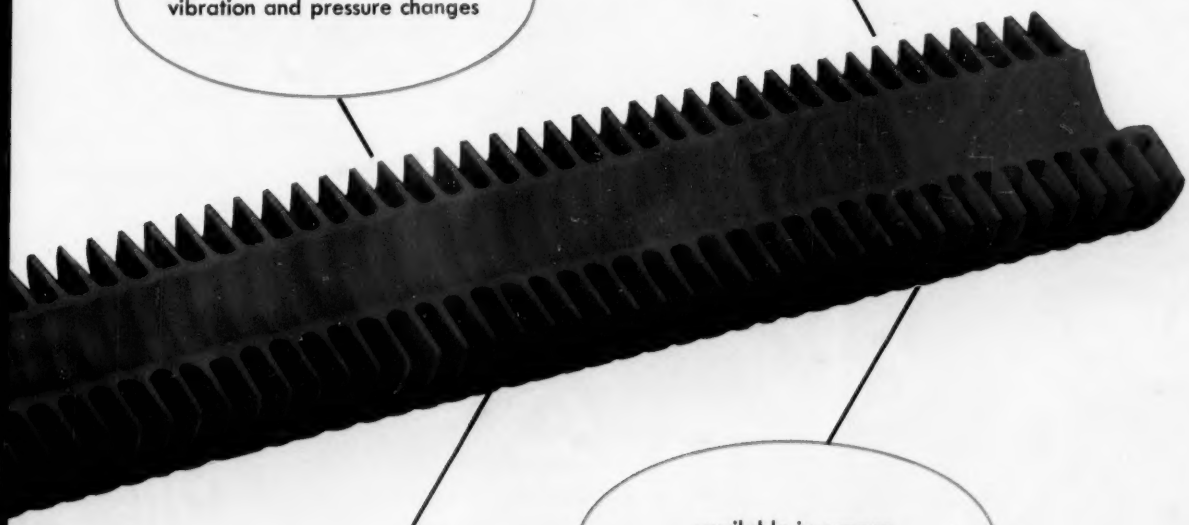
several types of end treatments available

high finned outside to inside surface ratios up to 8-1. (Types H/R, L/C, and I/L)

available with either high or low fins with a wide variety of fin spacings

smooth extruded fins eliminate sharp angles and crevices

fins stand up under thermal shock, vibration and pressure changes



available in copper, copper alloys and aluminum

more BTU's per foot of tube

THIS IS WOLVERINE TRUFIN!

Look at the advantages—see for yourself what Trufin can do for you. Specify it for new installations and for retubing at turn-around time. You'll do a bigger job . . . boost production . . . save money, too!

THE THINGS YOU MUST KNOW ABOUT FINNED TUBE

EXPERIENCE

Where finned tube and heat transfer experience is concerned, Wolverine Tube is the industry's acknowledged leader. Wolverine pioneered the development of integrally finned tube (Wolverine Trufin®) and over the years has produced millions upon millions of feet of this efficient extended surface for countless heat transfer installations throughout the United States.

HEAT TRANSFER SPECIALISTS

In addition to a fully staffed Field Engineering Service, Wolverine Tube also maintains Technical Heat Transfer Specialists in all major processing areas across the country. These men have all undergone intensive training in finned tube technology and have completed a Process Heat Transfer Course conducted by Donald Q. Kern, Wolverine consultant.

RESEARCH AND DEVELOPMENT

Wolverine Tube maintains the industry's most complete research and development facilities in Allen Park, Michigan. Here, day-in and day-out, research delving into all aspects of tubing manufacturing is carried out. Extensive research in finned tube and heat transfer has been conducted at the University of Michigan for many years in Wolverine's behalf. You can rest assured, as a result of all of these activities, that Wolverine Tube contributes its full share to the advancement of tubing technology. You can be sure, too, that because of these facilities you can place your complete trust in any product bearing the Wolverine name.

Next time you require finned tube—or have a tubing problem—consult Wolverine Tube. Either way you'll be sure of the finest product or soundest advice available.

Wolverine Trufin is available in Canada through the Unifin Tube Division, London, Ontario.

CALUMET & HECLA, INC.
CALUMET DIVISION
URANIUM DIVISION
GOODMAN LUMBER DIVISION
WOLVERINE TUBE DIVISION
In Canada:
CALUMET & HECLA OF CANADA LIMITED
WOLVERINE TUBE DIVISION
CANADA VULCANIZER & EQUIPMENT CO. LTD.
UNIFIN TUBE DIVISION

WOLVERINE TUBE
DIVISION OF
CALUMET & HECLA, INC.
17232 Southfield Road
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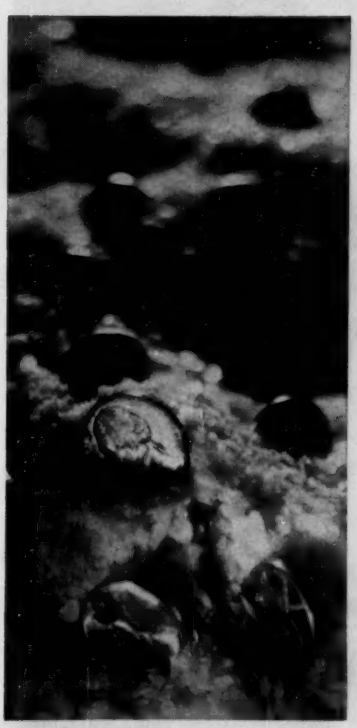
Manufacturers of Quality-Controlled Tubing and Extruded Aluminum Shapes

PLANTS IN DETROIT, MICHIGAN AND DECATUR, ALABAMA
SALES OFFICES IN PRINCIPAL CITIES

BRIEFS

sodium sulfhydrate vs. sulfide
a dependable organic solvent and intermediate
phosphorus pentachloride reaction



SAVE 6.3¢ A POUND

On the basis of combined sulfur, sodium sulfhydrate is a far better buy than sodium sulfide. You get 62.6% more sulfur for a given weight of both products, which gives the sulfhydrate an edge of 6.3¢ a pound.

But that's not all. Hooker sodium sulfhydrate has high purity, 70% to 72% NaSH, most of the remainder being water of crystallization. Metallic contamination is kept to the order of 1 ppm for Cu, Ni, Cr, Mn, Pb. As low as 5 ppm for Fe.

Other advantages: rapid-dissolving flakes, even in cold water; little or no sedimentation; low alkalinity as compared with sodium sulfide.

We always ship in new, lacquer-lined drums which have full-open heads. The inert lacquer lining protects the product completely during shipment and storage. The full-open head makes for maximum ease in handling and charging your process.

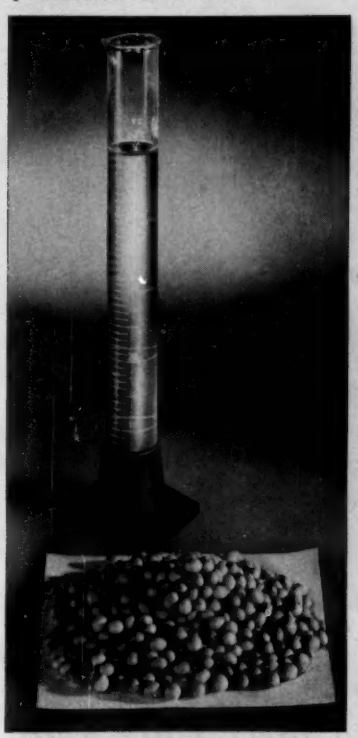
See coupon for data sheet.

A SPECIAL TRICHLOR... NIALK® EXTRACTION GRADE

When you're extracting natural substances like vegetable oils, waxes, animal fats, or botanicals, use a trichlorethylene that really fits your process.

Our Nialk® extraction grade boils between 86.6 and 87.4° C. Its acidity, as percent HCl, is zero. Alkalinity, as percent NaOH, is only .006 to .008. Free halogen—none. No cloud at minus 12° C.

Moreover, our product meets these specifications *at all times.*



Other uses? Nialk extraction grade makes a flame-proof solvent for adhesives, can be used as a "stopping" agent to control chain lengths in certain polymerizations or as an organic intermediate, and is used to extract caffeine from coffee.

Check the coupon for data sheet giving full information on specifications, description, and uses.

IT'S IN THE "JOURNAL"

If you've ever wondered about the mechanism for the reaction of phosphorus pentachloride with ketones, we refer you to the August 20, 1959, *Journal of the American Chemical Society* for an interesting article offering several equations you may find useful. Incidentally, we make phosphorus pentachloride, a yellowish crystalline powder with a melting point of about 148° C. under slight pressure. Ordinarily it sublimes at about 160° C. at atmospheric pressure. Among its uses: a substitute for the oxychloride to obtain tricresyl phosphate; as a general chlorinating agent and catalyst; for organic synthesis. It finds much of its usefulness in pilot plant applications where its solid state is suited to small reactors. Check coupon for data.

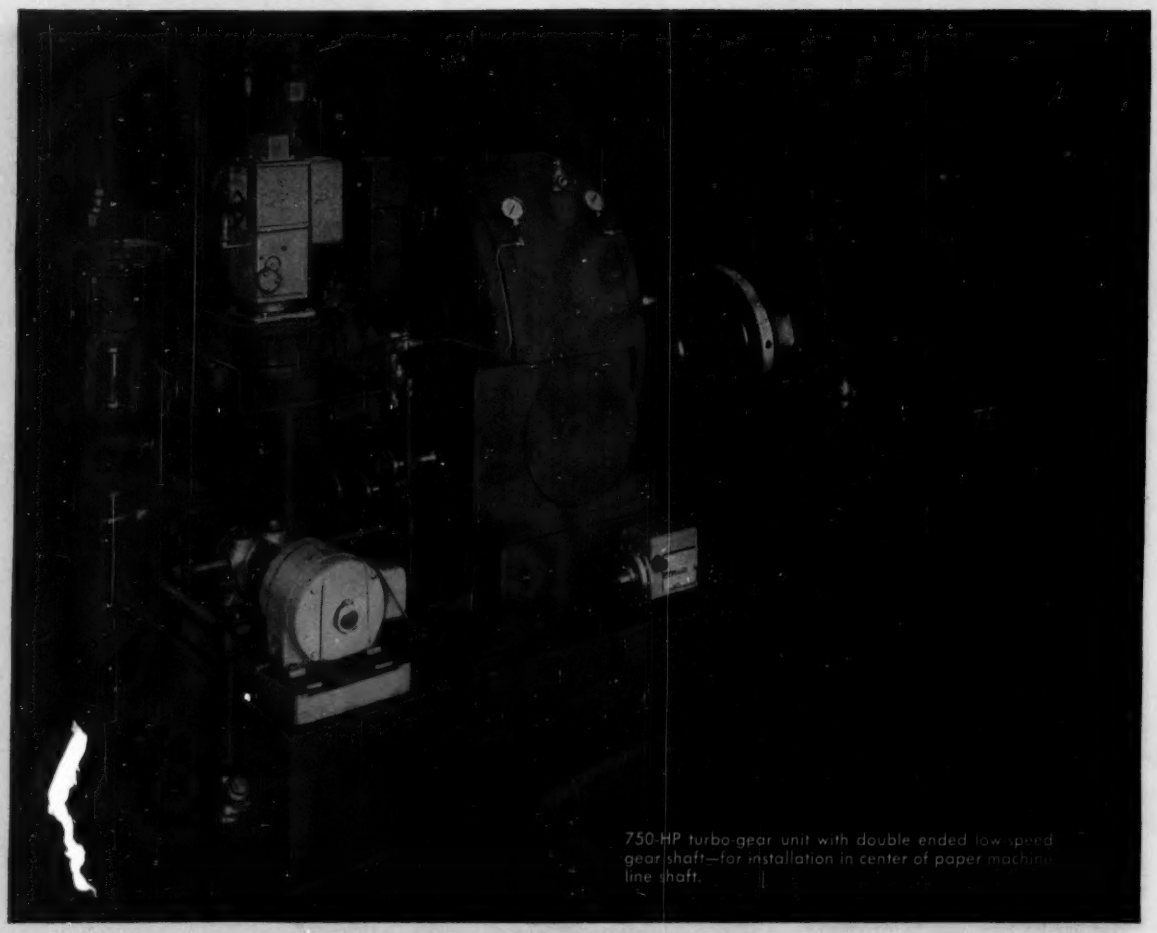
For more information, check here and mail with name, title and company address:

- ☐ Sodium sulfhydrate data sheet
- ☐ Sodium sulfide data sheet
- ☐ Trichlorethylene data sheet
- ☐ Phosphorus pentachloride data sheet

HOOKER CHEMICAL CORPORATION
408 Forty-seventh Street, Niagara Falls, New York

Sales Offices: Buffalo Chicago Detroit Los Angeles New York Niagara Falls Philadelphia Tacoma Worcester, Mass.
In Canada: Hooker Chemicals Limited, North Vancouver, B. C.

HOOKER CHEMICALS PLASTICS



750-HP turbo-gear unit with double ended low-speed gear shaft—for installation in center of paper machine line shaft.

LOW-SPEED TURBINE DRIVES

tailored to meet your requirements

For more than half a century, Terry has been one of the principal suppliers of turbo-gear units for driving slow-speed fans, generators, paper machines, large pumps and the like. Each unit is designed to meet the job requirements. The paper-machine drive illustrated is a good example of this *individualized engineering.*

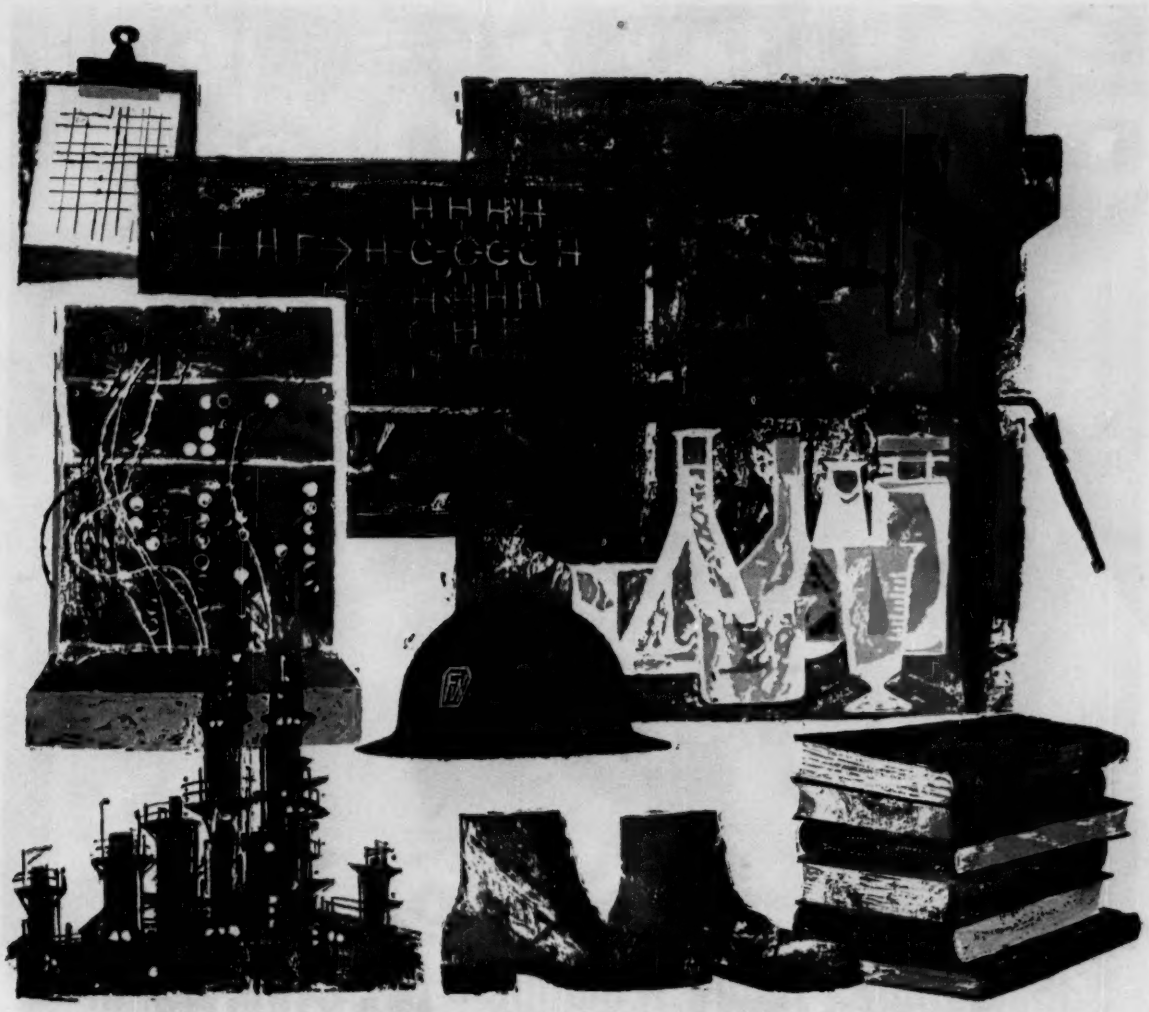
In service at a large southeastern paper mill, the unit delivers 750 HP at 3350/500 RPM, with steam conditions of 450 lbs., 660°F and 50 lbs. back pressure. Equipped with a variable-speed governor, operated by remote control, the speed of the unit may be varied through a 10:1 range. Other features include forced-feed lubrication to turbine and gear bearings, and automatic shutdown and alarm in case of low oil pressure.

Whatever *your* requirements for low-speed turbine drives, a Terry engineer will be pleased to discuss them with you. Bulletin S-140 covers the full line of Terry turbines; Terry gears are described in bulletin S-130.

THE TERRY STEAM TURBINE CO.
TERRY SQUARE, HARTFORD 1, CONN.

TERRY

TT-1212



a single source for all you need to make your process ideas succeed

Your ideas will thrive best in the company of people experienced in developing the ideas of others.

At Foster Wheeler you will find everything you need to make your process ideas a commercial success. There are men skilled in laboratory research and commercial evaluation to probe the practical possibilities of your ideas. To design and engineer your process plant there is a community of engineering professions—structural, heat and power, chemical, hydraulic, process . . . experts on pressure vessels and instrumentation . . . and people experienced in project management, plant construction and start-up.

From this comprehensive approach you can expect profitable operation at rated capacity soon after completion.

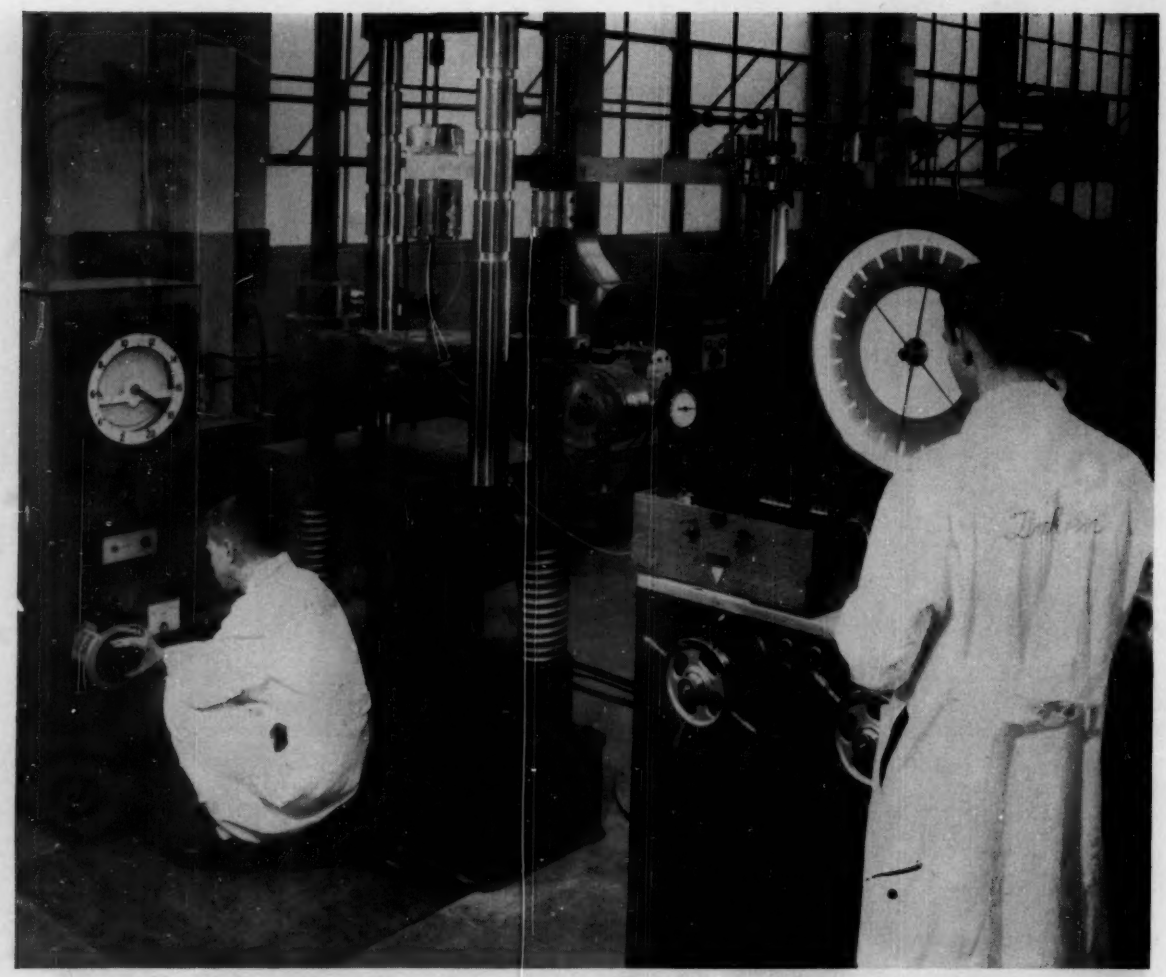
Two recent examples are plants delivered in good time and in good working order, operationally ready for quick write-off. They are a new ammonia plant producing in excess of 300 ton/day that exceeded rated capacity within 30 days of start-up; and a complete lube oil plant built in the Middle East which was in full production less than two years after award of the contract.

Before you specify, consult with Foster Wheeler. We are ready when you are. Foster Wheeler Corporation, 666 Fifth Avenue, New York 19, New York.

Heat Engineered products, plants and processes . . . for the world's industrial progress.

FOSTER WHEELER

NEW YORK LONDON PARIS ST. CATHARINES, ONT.



Here's where your "MAXIMUM TUBE LIFE PER DOLLAR" begins

If dollars didn't count, it wouldn't be too hard to buy steel tubing to stand up to pressure or corrosion, or any other conditions. Doing it economically is another thing. That's what the men above are making possible.

They're working with the hot tensile testing machine in The Timken Company's modern Metallurgical Research Center—testing steel under increasing loads (as high as 60 tons) at high temperature, until rupture occurs. It's just one way we pre-test steels to determine their performance in high temperature applications. Another assurance that you will get Timken® seamless steel pressure tubing having just the right analysis for your job. The one that will give you the best possible tube life per dollar.

When you buy Timken steel you get: 1) *Quality that's uniform from heat to heat, tube to tube, order to order—targeted to your end use.* 2) *Service from the experts in speciality steels.* 3) *Over 40 years experience in solving tough steel problems.*

Timken high temperature steel tubes are available in all stainless and alloy grades in sizes up to 11" O.D. by 3¼" wall. And Timken Company steel experts are always ready to help you select *the one* tube steel analysis that will give you *maximum tube life per dollar.* Call or write: The Timken Roller Bearing Company, Steel and Tube Division, Canton 6, Ohio. Cable: "TIMROSCO". *Makers of Tapered Roller Bearings, Fine Alloy Steel and Removable Rock Bits.*

TIMKEN®
Fine Alloy STEEL

TIMKEN ALLOY STEEL AND SEAMLESS STEEL TUBING ARE AVAILABLE FROM STEEL SERVICE CENTERS IN 44 CITIES IN THE UNITED STATES

ALL sizes
from 1 sq. ft. to 1000 sq. ft. filtering area.
ALL styles
flush plates & frames • recessed plates • hollow plates • solid center plates • retaining ring, packing ring & grooved joint plates.
ALL materials
cast-iron • aluminum • bronze • lead • nickel • rubber • stainless steel • wood • glass reinforced resins, etc.
Performance PROVED throughout ALL industries
SPERRY

in ALL ways...the simplest, most economical means of superior filtration!

Recognizing that no single type filter press will satisfy all requirements, Sperry makes available the broadest combinations of design features to help you achieve maximum efficiency and economy.

Briefly—the Sperry Filter Press can be equipped with any type of plates—made of virtually any material—to handle any filterable mixtures—and most filter media—over a wide range of temperatures, pressures and capacities—with center, side or corner feed—open or closed delivery—for filtration of liquids, recovery of solids, clarification and decolorizing.

Sperry also manufactures a complete range of plate shifting and closing devices—enabling one man to control the entire operation.

All this—at low first cost, low depreciation and minimum maintenance! Write for details or mail coupon for free Sperry catalog.

D. R. SPERRY & CO., Batavia, Ill.

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CRUSHING LIGHT AND ABRASIVE MATERIALS?

Pennsylvania CDL Series Reversible Impactors offer 5 unique advantages

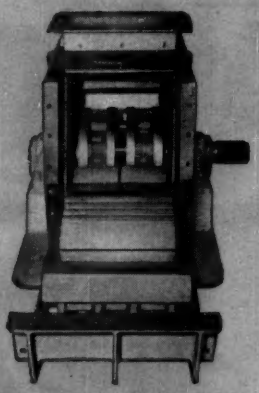
This is the crusher designed specifically for jobs where weight and ruggedness are unnecessary —such as crushing light and often abrasive materials. To plant operators with such job requirements Pennsylvania CDL Series offers:

1. Definite wear advantage accomplished by use of cast alloy steel in all hammers and breaker blocks. Side liners are of heat-treated carbon steel.

2. Adjustable upper and lower breaker blocks. In some series the upper blocks are reversible. Maximum control of circulating load and product gradation is achieved by merely moving upper and lower blocks closer to or further from the hammer circle.

3. Easy accessibility. The entire upper and lower breaker block assembly swings back, exposing the entire rotor assembly, thus holding maintenance time to a minimum.

4. Identical reduction. With breaker blocks located on both sides of the machine, and feed chute directly over center of the rotor, these units perform identical reduction when run in either direction.

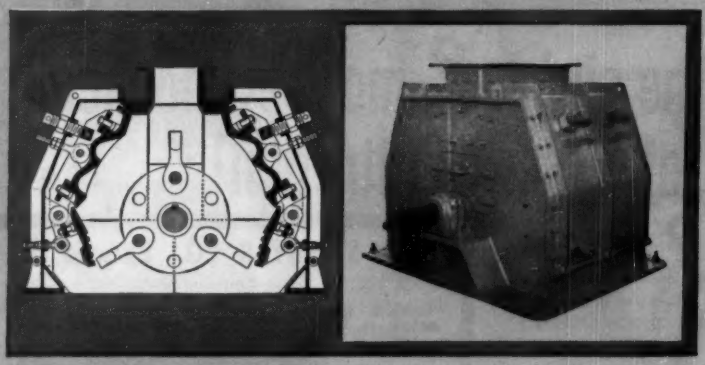


• Pennsylvania CDL 5-32 Reversible Impactor with breaker block assembly open to show easy accessibility.

5. Balanced wear. Systematic rotor reversal balances wear on both sets of breaker blocks and eliminates hand-turning of hammers—a major saving in maintenance costs for both parts and labor.

FREE BULLETIN

For full description of Pennsylvania CDL Series Impactors, as well as other Pennsylvania Reversible Impactors, write for Bulletin 6018.



• Pennsylvania CDL 7-38 Reversible Impactor

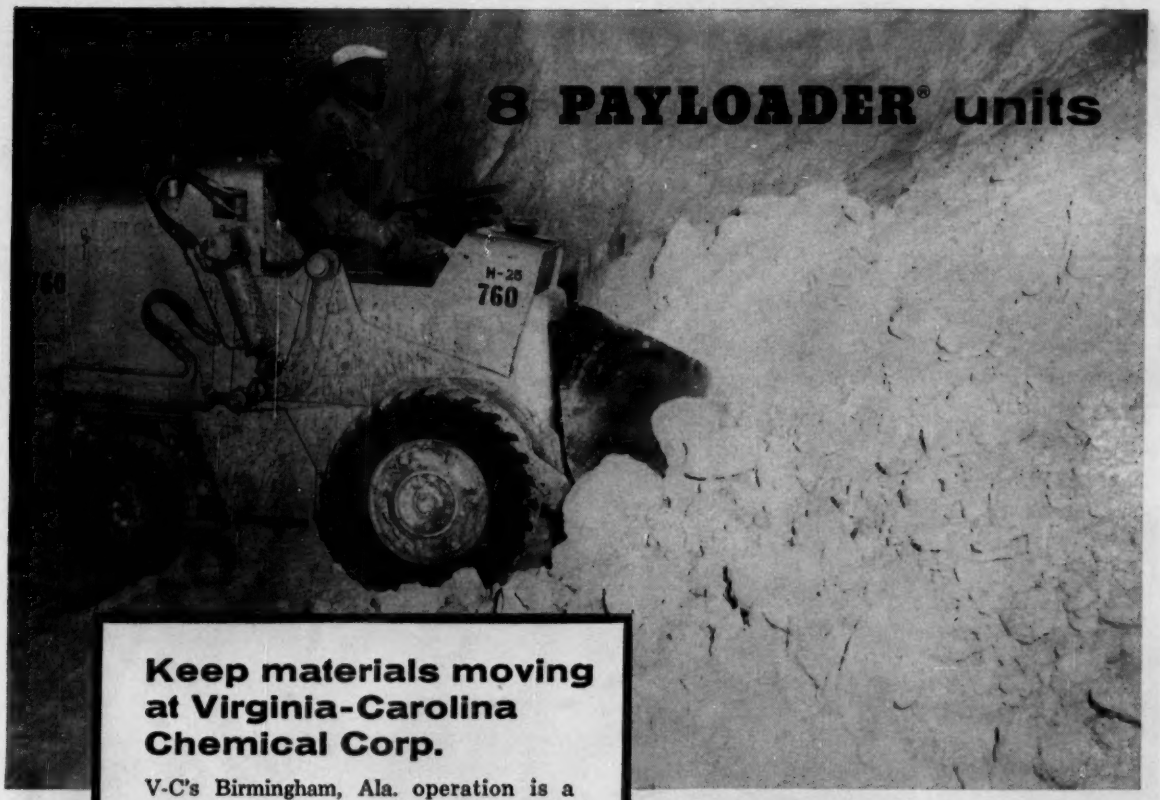
PENNSYLVANIA CRUSHER DIVISION
BATH IRON WORKS CORPORATION
WEST CHESTER, PENNA.

★ ★ ★

Over 50 years' concentrated experience in all types of material reduction makes Pennsylvania your best source of crushers and engineering advice and service. Call on Pennsylvania with your next crushing problem. Representatives from coast-to-coast.

PENNSYLVANIA CRUSHERS

BATH-BUILT



Keep materials moving at Virginia-Carolina Chemical Corp.

V-C's Birmingham, Ala. operation is a complete wet-mix manufacturing facility and includes a sulphuric acid plant. Eight "PAYLOADER" units are used for all phases of material handling, including the charging of sulphur to the melting vat, the moving of railroad cars, unloading potash from box-cars and in-process handling.

J. F. Lotz, Plant Superintendent says of his two newest units, "The Model H-25 'PAYLOADER' units are versatile and fast in all-around plant operations. They have twice the delivery capacity of the older Model HA's, and are faster in the storage pile."

Speed, capacity, maneuverability and ease of operation are combined in the H-25 for big production all day long. With only 6-ft. turning radius, it features 2,500 lb. operating capacity, power-shift transmission, torque-converter drive, power-steering, power-transfer differential and fast, powerful hydraulic bucket control. Closed, pressurized hydraulic system plus filters and seals throughout the machine assure effective protection in dusty conditions.

A nearby Hough Distributor is ready to show you what a "PAYLOADER" can do for your bulk materials handling.

HOUGH®

THE FRANK G. HOUGH CO.
LIBERTYVILLE, ILLINOIS
SUBSIDIARY — INTERNATIONAL HARVESTER COMPANY

4,500 lbs. of breakout power easily digs full bucket loads of hard super phosphate.

Spotting railroad cars is all in a day's work for the powerful, rugged H-25's.

HOUGH, PAYLOADER, PAYMOVER, PAYLOGGER and PAY are registered trademark names of The Frank G. Hough Co., Libertyville, Ill.

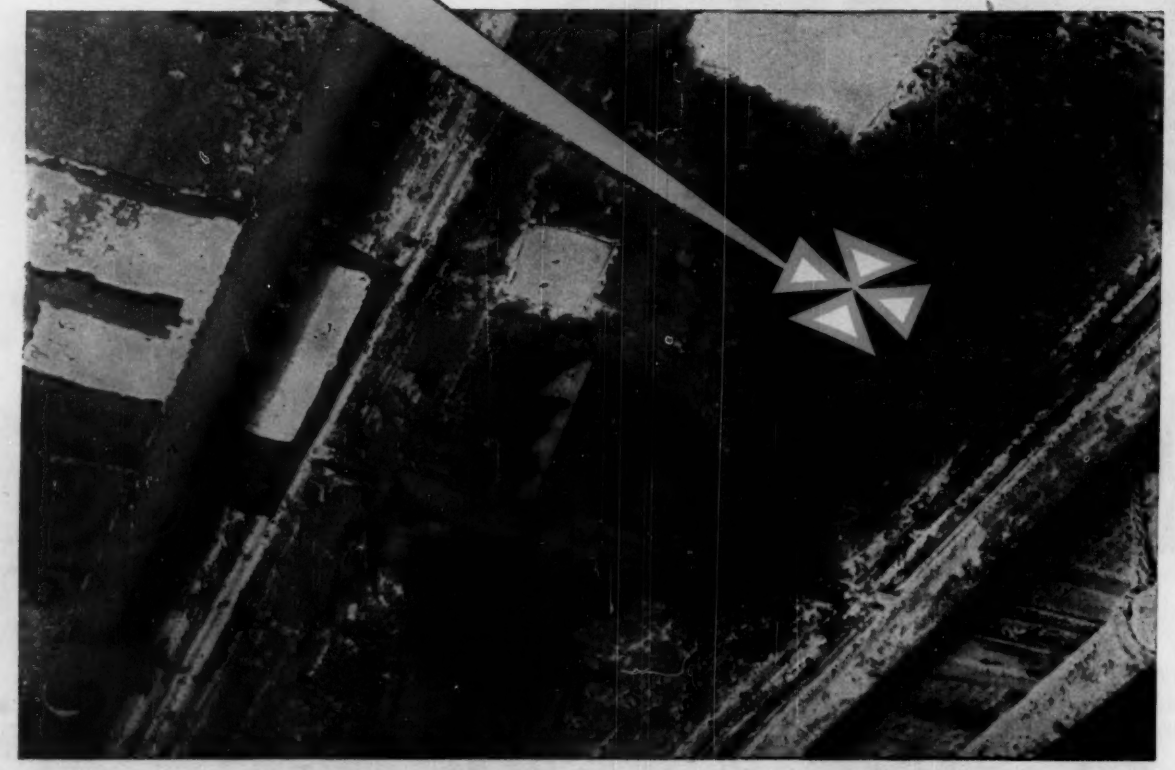
THE FRANK G. HOUGH CO. S-A-1
754 Sunnyside Ave., Libertyville, Ill.

☐ Send data on H-25 "PAYLOADER"
☐ Larger models — to 12,000 lb. operating capacity

Name.....
Title.....
Company.....
Street.....
City..... State.....

"X" MARKS THE SPOT

where a $1.05 saving went through the roof!



On a 250 gallon paint order, the Plant Maintenance Department figured to save $1.05 per gallon by using a paint that was cheaper, and "just as good" as Tygon. The cheaper paint *appeared* to be doing a good job — then the roof fell in!

These people learned the hard way what most corrosion engineers already know: the cheapest paint rarely gives the most economical protection. Where proven corrosion resistance is concerned, it's virtually impossible to find a paint that offers lower *cost per year per square foot of protection* than Tygon Paint.

Tygon Protective Coating Systems are designed for practical application of specialized protection against a wide range of specific corrosives and exposure conditions. The broad Tygon line includes vinyl-based coatings, as well as formulations based on epoxy resins. Depending upon the specific use for which each coating is designed, Tygon Paints provide more effective, longer-lasting protection against such corrosives as acids, alkalies, oils, water, alcohols and many solvents. Tygon is available for simplified, economical application by brush or cold spray — and in the Tygon "ATD" Series — by hot spray methods.

Properly applied and used under the specific conditions for which they are recommended, Tygon Coatings will outlast and out-perform practically any other paint available today.

Write for this free Tygon Data Book. It gives complete application details plus helpful information on resistance of Tygon to over 150 corrosives.

PLASTICS & SYNTHETICS DIVISION

U. S. STONEWARE

AKRON 9, OHIO

101-G

Tygon is a registered Trade Mark of the U. S. Stoneware Co.

DEVELOPMENTS . . .

AUGUST 22, 1960

Chementator

T. PETER FORBATH

Aluminium, Ltd., claims it has a radically new aluminum-making process that cuts capital investment in half. Firm is building a 7,000-ton/yr. experimental plant in Arvida, Que. No further process details are available.

Watch for a decision soon on the fate of Texas A. & M.'s solvent extraction route for desalting brackish water. Brown & Root, Houston, is submitting a feasibility evaluation to the Dept. of the Interior by the end of the month.

Enroute to making the U. S. self-sufficient in beryllium, Beryllium Resources, Inc., says it has developed a process for extracting the metal via acid digestion of Utah's topaz ores.

Industrial spying charged by two firms

The routine introduction two months ago of a new drug for control of poultry disease has suddenly touched off spectacular legal actions on both sides of the Atlantic. Merck & Co. charges in U. S. District Court in New Haven, Conn., that consultant R. S. Aries' new coccidiostat, mepyrium, is really the same as Merck's amprolyium and that Aries "unlawfully and surreptitiously" obtained data on the drug from Merck.

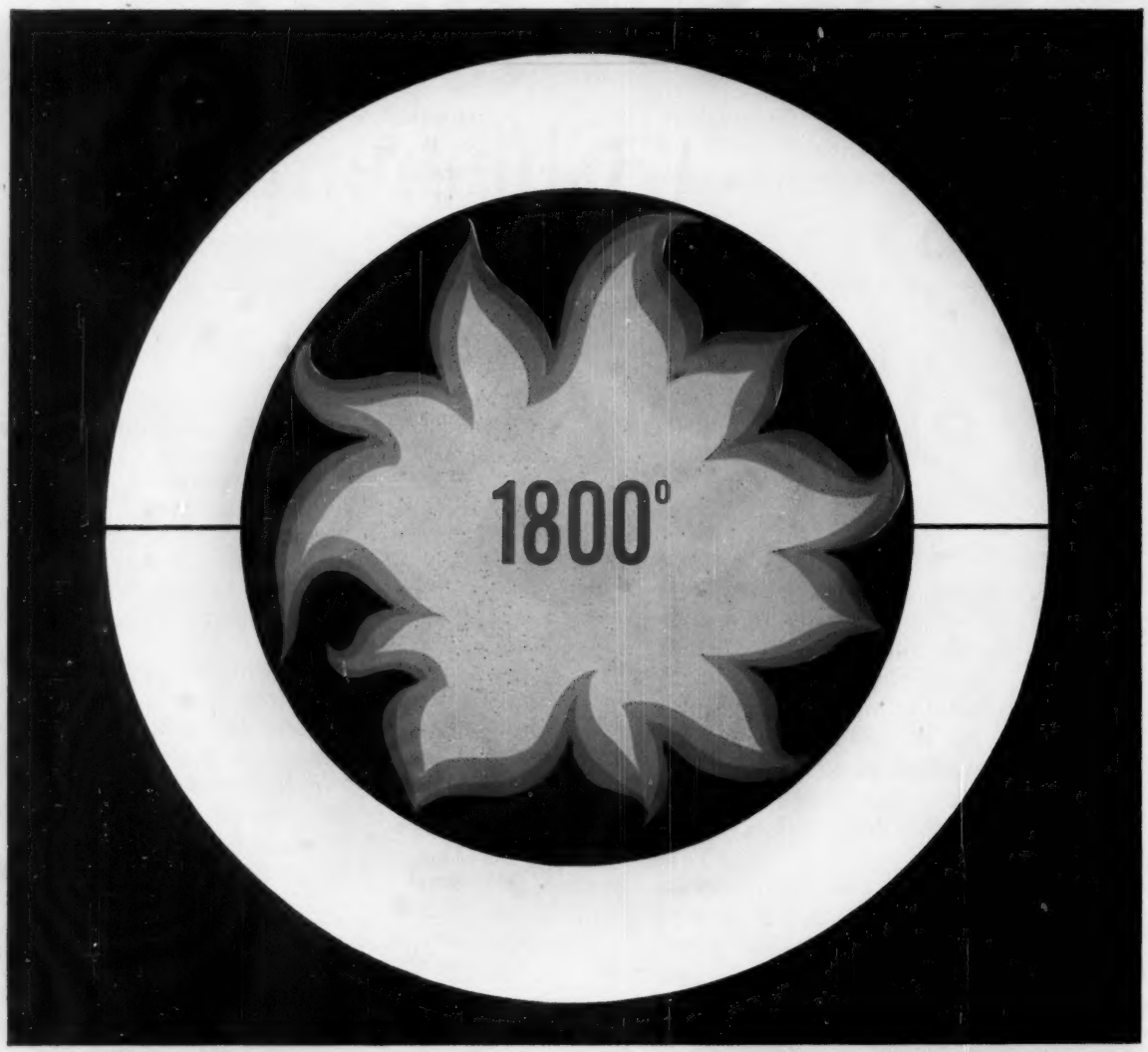
One of the defendants in Merck's suit, Swiss drug firm Chimel, S. A. (for which Aries is a consultant) has countered with a lawsuit in Paris. According to the Swiss drugmaker, its French rights to mepyrium were bought by Synorga, a French company. Then, says Chimel, Merck bought Synorga "at an inflated price" in order to get information on mepyrium.

Although Aries could not be reached for comment, a Chimel spokesman says it was completely surprised by Merck's suit. Chimel maintains it developed mepyrium through its own research and has patents in several countries. It is currently manufacturing mepyrium in Switzerland, is negotiating for its manufacture under license in other countries.

Merck's complaint contends that its own scientists developed amprolyium and that Aries obtained the data from its secret files. Merck learned of this, it says, through contact with Synorga. Merck has obtained an injunction impounding some of Aries' records and preventing further disclosure of "any information obtained from Merck." Company is also seeking damages in excess of $7.8 million for loss of proprietary information.

Jobs abound for engineering grads

This year's engineering graduates apparently haven't had the least bit of trouble parlaying hard-earned sheepskins into professional careers. According to a just-released Engineers Joint Council survey, by May 20—



NOW CALSILITE-HI TO 1800°F

New Ruberoid Calsilite-Hi insulation for soaking heat to 1800°F. It's light, strong and so economical it can be used on all types of jobs. Calsilite-Hi is ideal for both insulation and fireproofing.

Calsilite-Hi, a molded calcium silicate insulation, extends the Ruberoid insulation line to the upper temperature limit of 1800°F. Available in half-sectional, three segmental and block form, it can be used as fireproofing for walls, partitions and ceilings as well as insulation for piping and equipment.

Calsilite-Hi is light and easy to install. It cuts and mitres quickly, smoothly and is gentle on hands. What's more, it keeps its strength even when wet, does not soften or fall off. Returns to its original thermal efficiency when dry. Resists most chemicals and alkalis in industrial concentrations.

For additional specifications or samples of Calsilite and Calsilite-Hi insulation, write: The Ruberoid Company, 500 Fifth Avenue, New York 36, New York.

THERMAL CONDUCTIVITY
(BTU/sq. ft./inch/hr./°F.)

400°F. (Mean)	0.54
600°F. (Mean)	0.64
800°F. (Mean)	0.74

Density 13.5 lbs. per cu. ft.

Compressive Strength
5% deformation (Min.) 135 lbs. psi.

Flexural Strength 75 lbs. per sq. in.

Change under Soaking Heat
24 hrs. @ 1800°F.

Loss in weight	5%
Linear Shrinkage	1.5%

The RUBEROID Co.®

nearly a full month before graduation—more than 93% of the new engineers had specific career commitments or were considering definite job offers.* And EJC predicts that virtually all of the remaining 7% will be placed before summer's end.

Chemical engineers were in greater demand this year than in any of the previous three years that EJC has been conducting its Engineering Graduate Placement Survey. (Survey covers 220 educational institutions with nearly 15,000 new graduates.) In 1960, only 6.4% of the Ch. E. graduating class were still jobless when the survey was made. In 1959, 9.5%, and in 1958, 16.5% were so affected.

Of all new engineers, only the "electricals" proved more in demand than the "chemicals" this year. Only 5.4% of the E.E. grads were without career commitments or job offers as of May 20. And significantly, chemical engineering grads have been moving up fast during the last three years in the annual race for jobs. Of the 10 engineering disciplines surveyed by EJC, chemicals were in tenth place in 1958, seventh in 1959, second this year.

Here's how the new chemical engineering class breaks down: 61.3% have accepted professional positions, 10% are considering one or more definite job offers, 14.1% are going on to graduate school, 6.6% are entering military service, 1.6% have other specific plans and 6.4% are without plans.

* In contrast, only 88% of business and commerce graduates and 85% of liberal arts and science graduates were in a similar position.

New control tool: zeta potential

Improved standards for odor and taste of water treated from polluted sources may be possible because of a freshly exploited principle of physical chemistry. Initial tests to control zeta potential of colloids in water have just been made at the municipal water treatment plant in Waterford, N. Y.

Zeta potential—the potential at the hydrodynamic plane of shear—is a measure of electric charge at the surface of an ionized particle. Distributed in a diffuse double layer about the particle, the charge tends to attract ions of opposite sign, repel those of like sign. When zeta potential is reduced below a critical value, sols become unstable and produce flocs.

Flocculation is an important part of most water treatment and, commonly, pH is used to control chemical addition. For many cases of polluted water, however, pH has been unsatisfactory. It appeared to Thomas A. Riddick, New York engineer who designed the Waterford plant, that zeta potential might be a rational method of controlling flocculation.

Riddick, adopting electrophoresis and dark field microscopy, has designed a relatively simple lab technique to determine zeta potential. Water sample is introduced into a flat, rectangular plastic cell with platinum electrodes at either end connected to d.c. power. Migration velocity of colloidal particles is obtained by average stopwatch-timed passage of particles past an ocular scale under a stereoscopic microscope. Technique, which requires no specialized training, takes about five minutes.

After determining zeta potential from temperature-compensated curves, operators can adjust chemical treatment, following chlorination and addition of activated carbon, to reduce potential and obtain better flocculation.

Activity popping in porous plastics

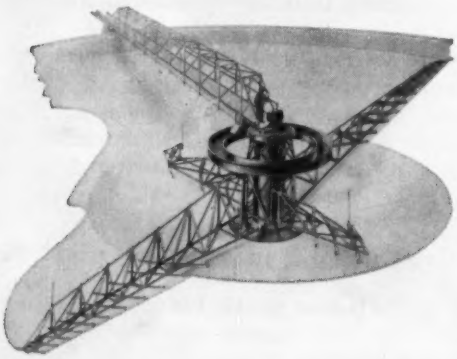
Another porous plastic has hit the marketplace. This one: porous nylon, developed by The Polymer Corp., Reading, Pa. Material currently is being commercialized by Polymer's subsidiary, Halex Corp., to compete with metals in the manufacture of oil-filled bearings and other wear parts that are used where low-friction lubricated surfaces must be maintained over indefinite periods without subsequent lubrication.

Polymer's development is the latest indication of the rising interest in the porous form of various plastics. Last year (*Chementator*, June 29, 1959, p. 39), ESB-Reeves Corp. announced the availability of thermoplastic sheet (e.g., polyvinyl chloride) containing 1 to 30-micron pores. Soon thereafter, the British firm Porous Plastics, Ltd., introduced high-density polyethylene sheet containing 100 to 200-micron pores. These materials are being aimed at such applications as "breathing" rainproof garments, filtration media, electrolytic diaphragms, and medical casts.

More recently, S. C. Johnson & Son reported that it's investigating a "microporous" polyvinyl chloride material that will hold liquid in its pores, release it at a controlled rate. Company visualizes the material being used in ink stamps, applicators for hair dyes and lotions, various lube jobs in industrial equipment.

Process Trends / from DORR-OLIVER

NEW DEVELOPMENTS IN SEDIMENTATION INVITE APPRAISAL



The technique of separation by sedimentation may be employed to produce a more or less clear liquor from a mixture of solids and liquid (clarification), or to concentrate suspended solids into a denser slurry (thickening). It may also be adapted to give fractional separation of particles of various sizes or specific gravities (hydro-separation).

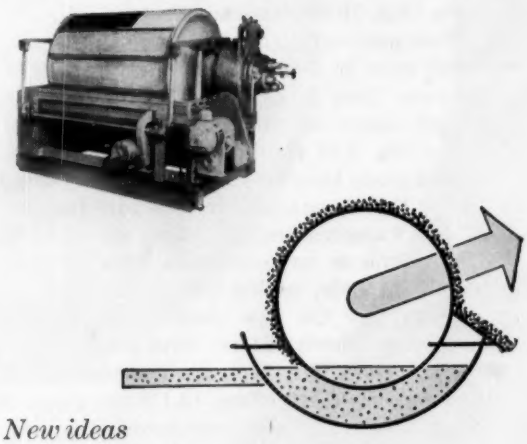
Modern continuous sedimentation systems, which substitute mechanical means for the old batch methods of slow gravity settling and decanting, date from the invention of the Dorr Thickener in the early 1900's. Developments such as multiple compartments and hinged rake arms, flocculation to promote economical handling of colloidal materials, and the combination of several operations within a single tank, have continually expanded scope and versatility.

A long-term project at Dorr-Oliver, aimed at increasing fundamental knowledge, has brought to light many previously unknown principles affecting thickener operation.

Relatively simple laboratory tests permit accurate prediction of performance. These developments have resulted in a new understanding of the potentialities of the thickener as a tool for the processing industries.

If your flowsheet offers opportunities where the unit operation of sedimentation may be employed, maybe a fresh appraisal of the various types of Dorr Thickeners is in order.

FILTRATION EXPANDS ITS SCOPE



New ideas and equipment increase potential

Pick any processed material and it's dollars to doughnuts that somewhere along the production line there's a filter.

Keeping on top of the many demands made on filtration equipment by modern processing often presents some tricky problems. Take corrosive applications, for instance. With rotary drum type filters, usual practice calls for stainless steel or rubber-covered construction. Capitalizing on advances in materials of construction, Dorr-Oliver engineers recently developed a filter with all essential components fabricated from tough, glass-reinforced plastics. The plastic construction not only resists corrosion, but it is also lighter and lower in cost than comparable standard machines.

This new filter has been successfully tested in handling acid leach solutions in a uranium mill and is now offered as a regular component of the Dorr-Oliver line.

This development is quoted as an example of the many contributions made by Dorr-Oliver to increase the scope and versatility of filtration equipment. Actually, it's just about impossible to think of any type of filter for any industry that hasn't been developed or improved by Dorr-Oliver engineers.

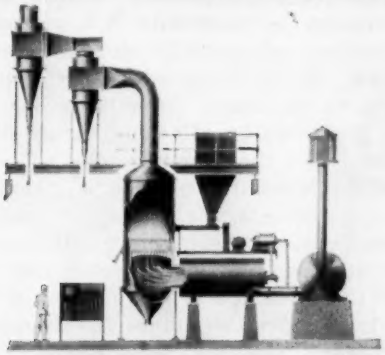
Dorr-Oliver engineers are constantly at work in these four fields. For help in solving any problems you may be encountering

Dorr-Oliver offers a wide range of equipment, methods and complete systems for processing industries.

Operations include: ROASTING • DRYING • CALCINATION •

A report on developments in equipment and methods of interest to the processing industries

WHAT'S NEXT IN SOLIDS FLUIDIZATION?



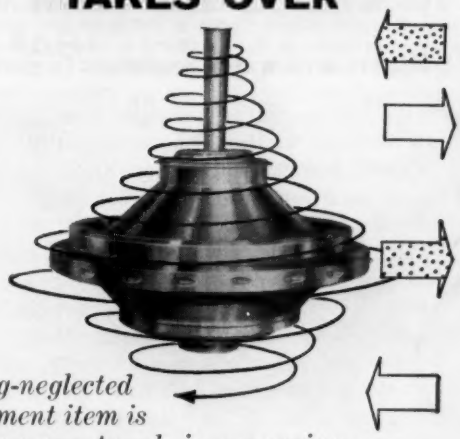
A versatile drying, roasting and calcining technique offers opportunities in chemical processing

Since Dorr-Oliver first introduced the fluidization technique for non-catalytic applications more than ten years ago, it has been widely applied in such operations as the roasting of sulphide ores, SO_2 production for acid manufacture, drying of fine coal and drying and sizing of limestone. Development is now extending into many fields of chemical processing.

The advantages of FluoSolids®, Dorr-Oliver's system for fluidized bed techniques, are its essential simplicity, its compactness, its low operating and maintenance costs, its ability to take wide feed variations and its inherent adaptability to precise temperature control with simple instrumentation. It has proved particularly effective in drying wet, sticky or otherwise difficult-to-handle materials. In some drying operations, the added benefit of classification by particle size is possible.

At D-O's research and development center, Westport, Connecticut, hundreds of test runs covering many possible new applications have been completed. Typical of these are the drying of heat sensitive polymers, drying of sodium chlorate crystals and potassium silicon fluorides, drying of chemical precipitates, roasting of furfural residues, and low temperature calcination of phosphates. Opportunities for still further development are far from exhausted.

THE CENTRIFUGE TAKES OVER



A long-neglected equipment item is starting new trends in processing

Centrifuges have now become so versatile in operation and have advanced so much in size, power and capability that opportunities for profitable application are virtually unlimited. In many cases, they are replacing filters, settling tanks, screening and other separation and classification equipment, cutting days off processing time. Important, too, since the centrifuge substitutes horsepower for size, is the greatly reduced floor space requirements and the smaller amount of critical material needed when handling highly corrosive solutions.

Dorr-Oliver has taken a leading part in the development of these newer, more versatile and more powerful units. Features of Dorr-Oliver design are the overhead bearing and drive which remove some of the limitations of conventional units and the revolutionary return flow principle that permits concentrating, washing, clarifying, classifying and recovery of soluble values at pressures up to 150 psi. Probably the largest centrifuge now in operation is a Merco® unit built by Dorr-Oliver. Rotor speeds up to 3300 rpm and capacities up to 600 gpm are possible. Smaller size, specialized units, among them the Mercone® Screening Centrifuge, are finding application in the food and pharmaceutical industries.

To those interested in the possibilities of centrifugation, Dorr-Oliver offers a wealth of information. For investigation and evaluation, pilot plant models are offered on a sale or rental basis.

in filtration, fluidization, sedimentation or centrifugation, write to Dorr-Oliver Incorporated, Stamford, Connecticut.

CLASSIFICATION • THICKENING • SCREENING • FILTRATION • CLARIFICATION
WASHING • AGITATION • CENTRIFUGATION • ION EXCHANGE • PUMPING

Polymer Corp. gets porosity in any nylon type (e.g., nylon-6, nylon-66) via a patent-applied-for compacting and sintering process that's similar to powdered metallurgy technology. Ultrafine powder (1-3 microns) is prepared from virgin nylon resin by a secret chemical reprecipitation technique. Powder is compacted in a mold at 15-50 tons/sq. in., then sintered at about 450 F. Sintering is carried out in a nonoxidizing atmosphere such as inert gas, vacuum, or under oil. If oil is used, wear part will be oil-filled after this step. If not, the part is oil impregnated after sintering.

Expert sees water resources in peril

Water treatment specialist Bernard Berger of the Taft Sanitary Engineering Center, Cincinnati, has challenged more than 100 top researchers in the fields of separation and purification to focus their talents on the critical state of America's water resources. Speaking at the 14th annual Gordon Research Conference in New London, N. H., Berger confronted his audience with the sobering thought that our water is not as pure as it seems. Not only do we not now have the tools to characterize the true quality of our water, but we also cannot raise that quality level if such is needed.

According to Berger, hundreds of industrial organic products ranging from process-plant effluents to chemicals applied to land, plants and animals are seeping into our water. No one knows what effect these impurities will ultimately have, or even what impurity levels are permissible. Neither does anyone know how to analyze for these chemicals nor how to remove them once permissible levels are established.

Welcoming ideas from all sources, Berger disclosed that he looks for development of a complete new technology of water treatment based on physical-chemical principles, supplementing biological processes currently used. In a drive toward this goal, the Taft Sanitary Engineering Center is about to award contracts for fundamental and applied research to several laboratories.

Chemicals improve sheep's handiwork

In a vigorous campaign to regain some of the apparel markets that wool has lost to synthetics, researchers are rushing to make wool a wash-and-wear fiber. Within a year, predicts the research-sponsoring Wool Bureau, woolen garments will be available with wash-and-wear properties equal to the best of today's synthetics.

The drive to improve wool's properties is proceeding along two avenues: (1) improving fabric geometry, (2) chemical treatment. Fabric Research Laboratories in Dedham, Mass., reports that great strides have been made, increasing shrink and wrinkle resistance merely by weaving cloth from yarns in which the wool fibers are relatively loosely packed.

After optimizing the structure of woolen fabrics, properties can be further improved by a two-step chemical process. Treating with 4% potassium permanganate in a saturated NaCl solution substantially eliminates area shrinkage. Following up with an ethanolamine-sulfite treatment imparts additional wrinkle resistance by attacking the disulfide linkage between the fiber molecules.

After this treated wool cloth is manufactured into garments, the maker can produce permanent creases by spraying with ethanolamine-sulfite, then pressing. There is just one cloud in this otherwise bright picture: if the synthetics improve their properties dramatically before the "new" wool bows in, wool might be competitively right back where it started.

Process taps "useless" ores

Heretofore uneconomic deposits of laterite and chromite ores, plentiful in the U. S. and Canada, may provide this continent with its first large source of ferro-chrome alloys for stainless steels. The Strategic-Udy electric smelting process, which has won fame as an iron-making route, is now being turned to making ferro-alloys from low-grade ores.

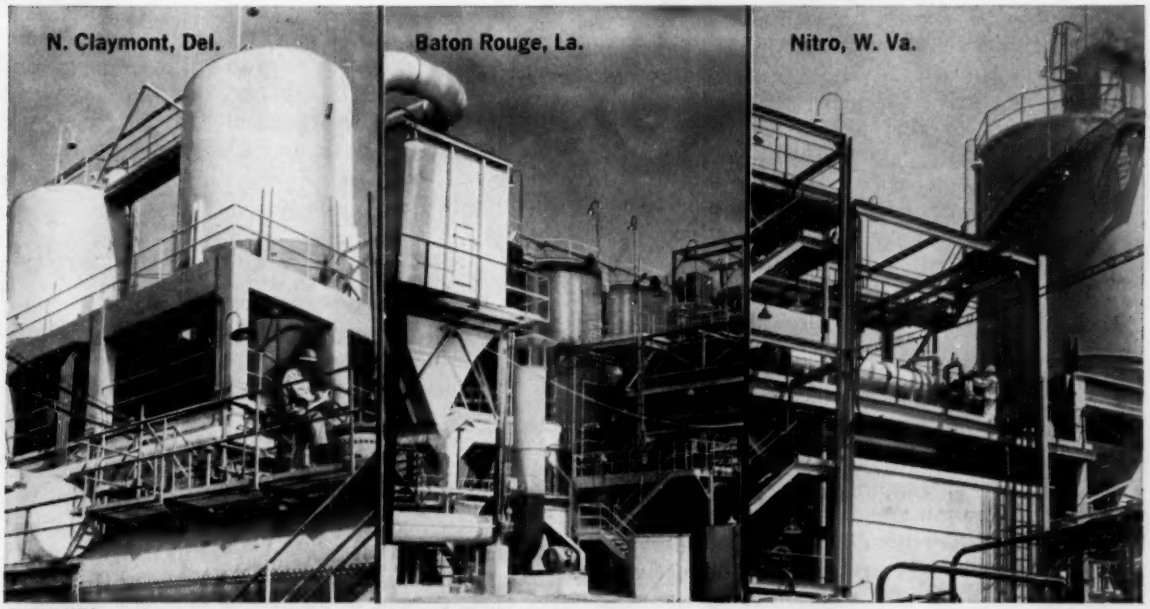
Most of our stainless is made from high-chrome ores (around 38% Cr) imported from Southern Rhodesia and Turkey. The domestic low-grade ores that Strategic will be treating, by contrast, contain only about 1% Ni, 1% Cr and 25-30% Fe.

Strategic Materials Corp. is now undertaking a $1.5-million expansion of its Niagara Falls, Ont., pilot facility along with Universal Cyclops Steel Corp. to make commercial lots (about 50 tons/day) of ferro-alloys. In addition, process produces low-carbon iron as a by-product that is suitable for finishing into steel.

The expansion is designed to be a showcase for this version of the Udy process. Some steel industry observers are skeptical of Strategic's cost figures showing the advantage of the Udy

BASIC REASONS FOR MAKING GENERAL CHEMICAL YOUR "HQ" FOR HF

EXTENSIVE FLUORSPAR RESOURCES. Basic to the point of owning large fluorspar reserves as well as mines and mills, General Chemical is the nation's leading producer of hydrofluoric acid. By controlling its raw material resources, General Chemical protects you against interruptions of supply.



3 PLANTS. General Chemical produces anhydrous and aqueous hydrofluoric acid at the following three locations: North Claymont, Delaware; Nitro, West Virginia; and Baton Rouge, Louisiana.

5 STOCK POINTS. General has five bulk storage and packing stations in the United States for aqueous HF. Each backs up the others—assuring availability and prompt service at all times.

With its outstanding resources for essential raw materials—fluorspar reserves, mines and mills—plus a broad network of 18 sulfuric acid plants, General Chemical's *basic* position in hydrofluoric acid production is unmatched.

What's more, General is the *only* supplier offering shipment of hydrofluoric acid from more than one producing location. It supplies *anhydrous* and *aqueous* HF to its customers from *three* producing works and *aqueous* HF from an additional *five* company-owned locations.

Whenever and wherever you need hydrofluoric acid, call on General Chemical—your "HQ" for HF!

Allied Chemical

GENERAL CHEMICAL DIVISION
40 Rector Street, New York 6, N. Y.

smelting route on low-grade ores. Strategic hopes this large installation will definitely prove that these low-grade deposits can be exploited profitably.

Cheaper SiC wins new applications

With high hopes of cracking the long-coveted aluminum cell market, Norton Co., Worcester, Mass., announces a new, cheaper nitride-bonded silicon carbide refractory. Christened Crystolon 63, the new material will cost only $3.09 per 9-in. brick, compared with current price of about $4.12 for comparable nitride-bonded SiC.

Norton expects the major application for Crystolon 63 to be in the lining of aluminum reduction cells, replacing present thick carbon linings. Nitride-bonded SiC has been considered for this application for some time (*Chementator*, July 13, 1959, p. 72), but its cost has prevented penetration of this lucrative market. Among other applications proposed for Crystolon 63 are molten-metal transfer systems—pipe, valves and even pumps.

Silicon carbide's advantages in the aluminum cell application are its insolubility in molten cryolite; higher electrical resistivity, cutting power loss through cell wall; reduction of cell wall thickness, allowing greater throughput per cell; and long operating life.

Originally, it was believed only the walls of the cell would be lined with SiC, leaving carbon on the bottom for cathode action. New titanium or zirconium diboride cathodes under development by several companies, however, will operate directly in the molten aluminum bath, allowing complete SiC lining.

Someone may want all that CO_2

If the new secondary oil recovery process developed by Oil Recovery Corp., Tulsa, Okla., wins wide acceptance, natural gas producers in the Southwest will have an outlet for at least part of the millions of cubic feet of CO_2 which are scrubbed out of natural gas each day.

In the Orco process, water saturated with CO_2 is injected into the ground to force oil to the surface. Process is claimed to recover more oil, does it faster than conventional water flooding. To supply customers in West Texas' Permian Basin, Orco's subsidiary West Texas CO_2 Co. is building a $500,000 CO_2 liquefaction plant near Fort Stockton, Tex.

Scheduled to go on stream this fall, the new facility will turn out 140 tons/day of liquid CO_2, which will be trucked in special 20-ton trailers to the wellhead. Plant will buy its CO_2 supply from neighboring Permian Basin Pipeline Co.'s huge CO_2 removal plant. Permian's natural gas feed, owned mainly by Phillips Petroleum, contains about 28% CO_2, which is now being vented to the atmosphere.

High CO_2 content of the newer natural gas fields has confronted producers with ever-higher processing costs. El Paso Natural Gas, for example, will be treating a 53% CO_2 natural gas in its new Fluor-process plant in Terrell County, venting 110 million cu. ft./day of CO_2.

El Paso, as well as other gas producers, has been searching for ways to utilize these waste CO_2 streams. If the Orco process provides buyers for at least part of this CO_2, some of the high-CO_2 fields may not seem so unattractive.

Papers set for "new engineering" parley

Final program has been worked out for the two-day symposium on The New Chemical Engineering, to be jointly sponsored this fall by Midwest Research Institute and *Chemical Engineering* (*Chementator*, May 16, p. 74).

Set for the Muehlebach Hotel in Kansas City, Mo., on Nov. 29 and 30, the pioneering meeting will feature ten key technical papers on new mathematics, new chemistry and new engineering techniques. Sessions will be kicked off with a keynote address by S. D. Kirkpatrick, vice-president of the McGraw-Hill Book Co., consulting editor of the McGraw-Hill series of chemical engineering texts and former editorial director of *Chemical Engineering* and *Chemical Week*.

Engineering session papers will include: Systems Engineering by T. C. Wherry of Phillips; Process Kinetics by Henry Eyring of U. of Utah; Information Retrieval by J. W. Perry of Western Reserve. Two other engineering papers will be presented at the symposium: one on process statistics, one on operations research.

Mathematics and chemistry papers are: Survey of New Mathematics by J. S. Dahler of U. of Minnesota; Numerical Analysis by Y. Luke of Midwest Research; Mathematics of Control Loops by T. J. Williams of Monsanto; Survey of New Chemistry by E. T. McBee of Purdue U. and a paper on solid state chemistry.

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Pump Size and Type	Capacity 60' Head RPM	HP	*Water GPM	Dimensions (In.) L	W	H	Approx. Ship. Wt. Lbs.
GLAND TYPE							
1½"x1¼"	2190	1.9	40	25	17½	26	525
2½"x2"	1500	4.9	160	25½	17½	26⅜	575
3" x3"	1400	6.8	260	31¼	19¾	31½	850
5" x5"	1060	17.4	800	37¾	26¼	36½	1550
6" x6"	1170	36.3	1600	45¼	28½	46½	2300
3" x3"—C	1450	8.2	260	37½	21½	33¾	1240
5" x4"—C	1035	12.6	700	40¼	27	37⅜	1600
8" x6"—C	920	39.8	1600	63	36½	49¼	4375
10" x8"—C	820	74.0	3300	68¾	43	57	5100
12" x10"—C	615	115.0	5000	69⅝	46½	63	5900
GLANDLESS TYPE							
3" x3"—C	1450	10.0	180	37½	21½	33¾	1240
5" x4"—C	1035	15.0	500	40¼	27	37⅜	1600
8" x6"—C	920	47.0	1200	63	36½	49¼	4375
10" x8"—C	820	87.0	2700	68¾	43	57	5100

*Based on water. Multiply horsepower by specific gravity of pulp to obtain actual brake horsepower.

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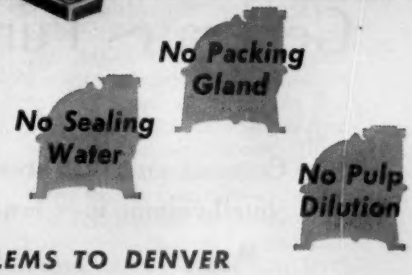

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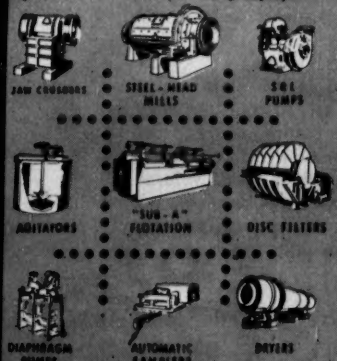

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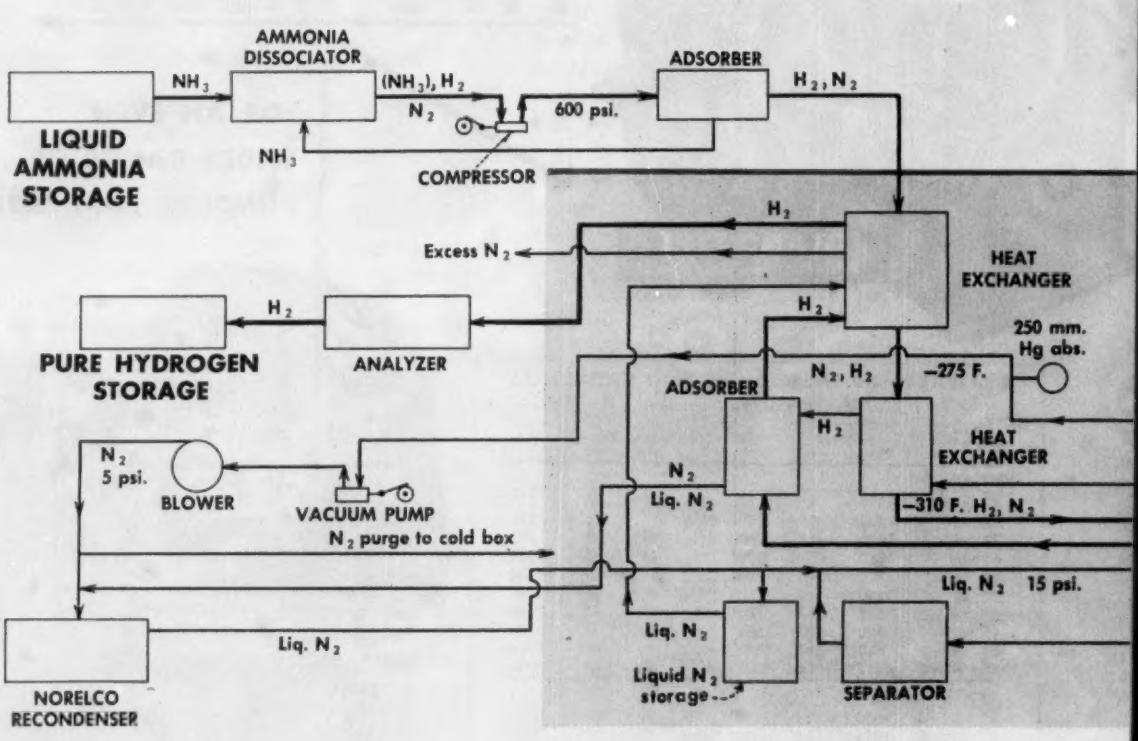


Generates Pure Hydrogen Right in Plant

Compact unit that breaks down ammonia, then separates out hydrogen, gives small-volume user low-cost product on demand.

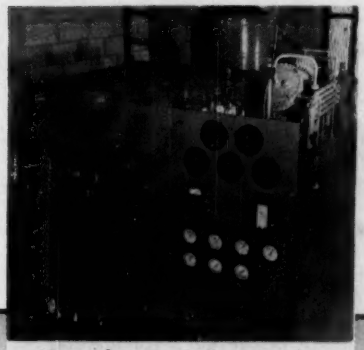
Ultrapure-hydrogen users who largely depend on cylinder supply (unless they are next door to an electrolytic hydrogen plant) can now put a unit in one corner of their plant and produce 99.995% pure hydrogen, on demand, from dissociated ammonia.

Cryogenerators, Inc. (subsidiary of North American Philips Co.), which developed and built the unit, claims that it's the first small-volume generator which can deliver high-purity hydrogen at a price competitive with the electrolytic product.

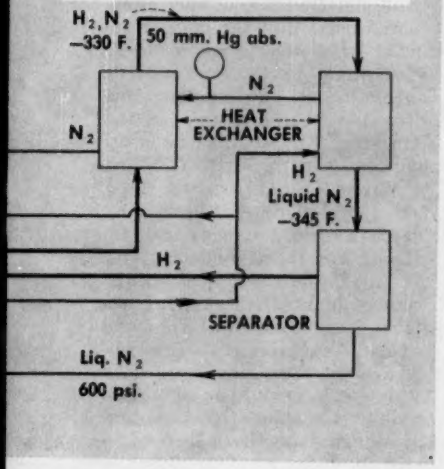
Commercial Steel Treat Co. agrees, put the first unit in its Detroit plant to supply 4 million scf./yr., which previously was hauled to the plant in cylinders. This company, which had been paying approximately $10/M scf. for an equal quantity of cylinder hydrogen, expects to make high-purity gas for about $3/M scf., plus amortization.

The $85-95,000 plant can produce up to 10 million scf./yr. (Cryogenerators designs units for up to 60 million scf./yr., which is still a small volume in a compressed gas business where 600-2,400 million scf./yr. capacities are usually the rule.)

COLD BOX



Heart of process is Cryogenerator which liquefies the nitrogen.



▶**A Definite Advantage**—Hydrogen made by this route has an inherent advantage over the electrolytic product for metal-treating service. Its chief impurity is nitrogen (less than 50 ppm.), which apparently has little or no effect on the treating process. Most commercial hydrogen has traces of oxygen or hydrocarbons that, unless held to a definite minimum, can affect the metal being treated.

How is it possible to make hydrogen-from-ammonia pay off? Separation of ammonia into its components by heating it in the presence of ferric oxide catalyst is well known. Once you get the hydrogen and nitrogen gases, you simply cool the mixture until liquid nitrogen forms, then separate the phases to get pure hydrogen gas.

The trick is in cooling. Cryogenerators supplies refrigeration with its patented Norelco Cryogenerator (or recondenser), which uses cold helium to get the low temperatures required. The Norelco unit employs the principle of the modified Stirling cycle as described below.

▶**Refrigeration Cycle** — Business part of the recondenser comprises two pistons working in a single cylinder. Around the cylinder in annular rings are a heat exchanger and a regenerator in which heat is stored. Top of cylinder, or dome, is also surrounded by heat-exchange fins.

In operation, the pistons move together in lower part of cylinder and compress between them the working medium (helium, in this case). Compressed gas flows out of the cylinder into the heat exchanger where cooling water removes the heat of compression.

The compressed gas then flows to the regenerator and gives up heat to the cold porous cells. From here, the chilled helium passes into the dome above the top piston. When this piston is drawn downward, the gas expands rapidly and its temperature plunges.

At this point, nitrogen gas, passing over the fins outside the dome, is quickly condensed by the extremely cold helium. Latter is then pushed back into the regenerator by the upward movement of the piston. Here it absorbs the heat left earlier in the cycle, leaving the regenerator once more frigid. The helium then passes into the lower part of the cylinder, between the two pistons, and is ready for another cycle.

▶**How Cold Makes Hydrogen**—We have seen how the recondenser makes cold, let's now see how the cold makes hydrogen. Dissociated ammonia, after compression to 600 psi., passes through an adsorber which removes any undissociated product. It then flows to the cold box (term for unit which contains all the low-temperature equipment) where it is cooled to –275 F. by the cold product streams.

Intense cold comes in the next section, where a series of three heat exchangers chill the feed with liquid nitrogen boiling at –310 F. (atmospheric pressure), –330 F. (250 mm. Hg abs.) and –345 F. (50 mm. Hg abs.). The stream, now mostly liquid nitrogen and gaseous hydrogen, passes through an entrainment separator and an adsorber, which remove the nitrogen.

The cold, purified hydrogen (final product) then absorbs heat from the incoming feed stream until it is within 5 deg. of ambient temperature. A hydrogen analyzer continuously checks its purity as it comes out of the cold box, and if it doesn't meet specification, it is automatically recycled through the process. Sufficiently pure gas, at 600 psi., is ready for storage or use.

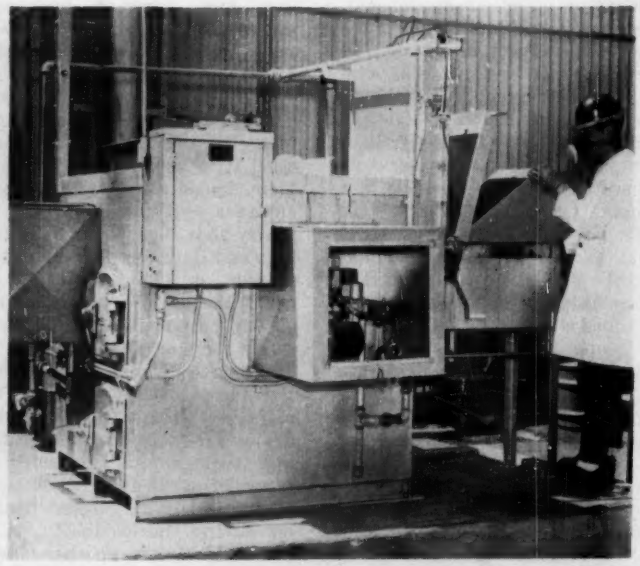
▶**Nitrogen Does the Work**—Workhorse of the system is the nitrogen. Liquid nitrogen that drains from the hydrogen-nitrogen separator is expanded to lower pressure in another separator. Dissolved hydrogen flashes off during the expansion, to be combined with another small hydrogen stream described below.

The adsorbers, which strip the final nitrogen from the pure hydrogen, work in tandem—when one is on stream, the other is regenerated by a stream of pure hydrogen. This clean-up stream, joining that flashed from the nitrogen expansion, returns to the feed compressor for recycling.

Low-pressure nitrogen vapors from vacuum exchangers are exhausted through feed heat exchanger, pressured to 5 psi., and split into two streams. One part serves as a purge on the cold box to keep out air and moisture. The other goes back into the system through the recondenser which converts it back to liquid.

▶**Automatic Controls**—The system includes all necessary pressure relief valves, gages and thermocouples, and liquid level controls needed to control the process.

Liquid nitrogen is used throughout the cold box to immerse the separators, adsorbers and heat exchangers. A supply is always maintained in a large storage Dewar flask to furnish coolant to the system for a rapid startup. Any excess nitrogen is available to the treating plant for purging or inert atmosphere control.



Incinerator Cuts Cost of Atom-Waste Disposal

Incinerator shown above, designed by General Electric Co., is expected to slash the cost of disposing contaminated wastes from nuclear-fuel manufacture by as much as 75%. Now in use at GE's Atomic Power Equipment Dept., San Jose, Calif., incinerator burns atom waste at the rate of 100 lb./hr., reduces it to 10% of original volume.

Heart of unit is a high-temperature furnace box that completely burns all combustible material. Spray-cooling equipment cools gases from the furnace, protects a high-efficiency gas filtration system from heat damage. Filtration system, designed even to stop bacteria, traps all radioactive particles in the exhaust gases.

European Firms Enter Natural-Synthetic Rubber

Taking their cue from lively U. S. activity in the field, at least three European firms have announced plans for getting into the natural-synthetic rubber business. And industry observers predict that these moves will trigger a rash of others in Western Europe.

A French company, Societe des Elastomeres de Synthese, reports it's now in the blueprint stage on a 25,000-ton/yr. polybutadiene plant. Facility will be constructed in Berre (near Marseilles) close to the company's abuilding 50,000-ton/yr. GRS rubber installation. The company is a joint venture of Cabot, Texas Butadiene, St. Gobain, Michelin, Dunlop, Kleber-Colombes and Shell Oil.

Shell Netherlands Chemical Factories has begun construction of a polyisoprene and polybutadiene plant at Pernis (near Rotterdam). And Chemische Werke Huels has recently indicated its intention of constructing Germany's first polybutadiene installation.

New Nuclear Fuels May Better A-Power Economics

Search for better nuclear fuels is fast becoming one of the major concerns and activities of the struggling atomic energy industry. Faced with a crying need to cut costs if they're ever to put nuclear power on a commercial basis, engineers are taking a hard second look at the fuel element itself as a relatively unexplored portion of the nuclear reactor which might be made to yield important economies.

Significant advances in this direction were reported at the American Nuclear Society meeting held last month in Chicago.

Martin Co. (Baltimore, Md.) has found that by adding tiny fibers of molybdenum to uranium dioxide the thermal conductivity of this "common" fuel can be boosted markedly. Company has fabricated uranium dioxide fuel elements containing 10-20% molybdenum fibers and swaged in stainless, zirconium or aluminum claddings that offer 30-60% improvements in thermal conductivity.

A favored fuel because of its radiation stability, chemical inertness and ability to retain fission products, uranium dioxide ordinarily exhibits a distressingly low thermal conductivity. This drawback is usually overcome by forming UO_2 into cermet elements. But this approach so dilutes fuel content that costly enriched uranium must be used if the fuel is to be usable. Martin's technique permits use of natural uranium, can be formed into elements simply and inexpensively by swaging. Uniform distribution in element is obtained by wetting molybdenum fibers and adding UO_2 gradually, company reports. And damp mixture can be pressed into tubes or compacted into pellets in high densities and with a minimum of swaging reduction.

Other work on new nuclear fuels includes investigation of uranium carbide, thorium dioxide-bismuth systems, various cermets and metal alloys.

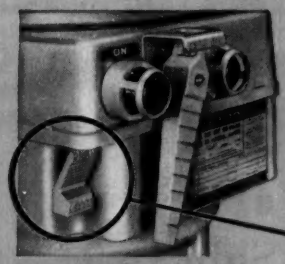
SQUARE D SPIN TOP® ENCLOSURE NOW MORE VERSATILE THAN EVER!

DAMAGE-RESISTING Acme threads. If you've struggled with "banged-up" threads, you'll appreciate this feature. It's always a breeze to put on and take off tanks for installation, inspection or maintenance.

FULL WEATHER PROTECTION • Male threads on collar engage female threads on tank—no external threads to be damaged.

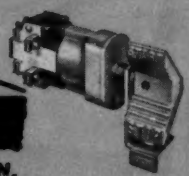
NEW! ***CONTROL TRANSFORMER*** can be mounted in collar. No special-length tanks required.

INCREASED WIRING SPACE • Four conduit openings standard, with through-feed conduit entrances for horizontal tap-offs optional.



NEW! ***SELECTOR SWITCH*** is made in one piece, installs simply by threading into opening provided in enclosure. One-piece construction permits pre-testing before shipment.

NEW! ***RECESSED CONTROL STATIONS*** like the reset button are out of the way, have no protrusion to break or bend accidentally.



NEW! ***PUSHBUTTON,*** like the selector switch, features one-piece construction for easy installation. Heavy-duty contacts and rugged mechanism assure long life.

NEW! ***BRILLIANT PILOT LIGHT*** is visible from all angles and provides easy bulb change. Enclosure available with either one or two factory-mounted lights or can be furnished with plugged holes for field installation. Stainless steel thread-in-thread construction gives corrosion-resistance and easy servicing.

EASY TO INSTALL with *slide and hook* mounting arrangement for interior equipment—a Square D "exclusive." Takes the hard work out of the installation job.

STRONG AND LIGHTWEIGHT construction. Complete enclosure is cast aluminum. All operating shafts are stainless steel, thread-in-thread, for the best in corrosion resistance.

Square D *is Better in So Many Ways!*

When you buy from Square D, you not only get all the benefits shown above—you also are buying from the only manufacturer who builds both the enclosure and the starter, giving you unit responsibility. Moreover, Square D offers better stocks, better on-the-spot service. That's why it makes sense to insist on Square D Spin Top enclosures for your hazardous location applications.

4 ENCLOSURE SIZES ACCOMMODATE NEMA SIZES 0 THROUGH 5

Square D Spin Top enclosures are NEMA 3 (weatherproof), NEMA 4 (watertight), NEMA 7 (explosion-proof) and NEMA 9 (hazardous locations) for Class I, Group C and D; and Class II, Groups E, F and G service.

Write for Bulletin 9990. Square D Company, 4041 North Richards Street, Milwaukee 12, Wisconsin

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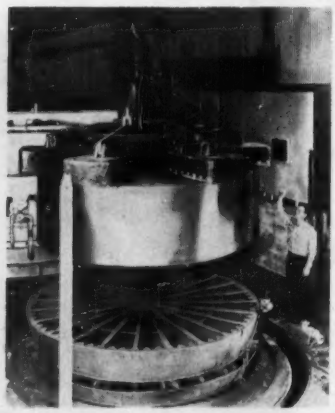
Battelle Memorial Institute (Columbus, Ohio) reports that columbium-uranium alloys make for excellent high-temperature-resistant nuclear fuels, eminently suited for use in high-temperature, high-efficiency compact nuclear reactors (e.g., gas-cooled units). Declares BMI, a columbium alloy containing 20% by weight uranium metal maintains high tensile strength and hardness at temperatures in the range of 1,600 F. Best current metallic fuel elements become unusable at temperatures above 1,200 F. Moreover, the columbium alloys exhibit high-thermal conductivity and corrosion resistance, retain fission gases and can be readily fabricated by standard manufacturing techniques.



Better Steels For Less Money

When the Lee Wilson Engineering Co., Cleveland, developed its open-coil process for speeding annealing operations, it also discovered it had accidentally solved the long-pondered problem of how to chemically alter steel sheet after it had been rolled.

Now called the open-coil gas-alloying process, the new scheme makes it possible to remove or add carbon, nitrogen or any other alloying element that can be gasified during annealing. In effect, the process makes possible the production of superior steel sheet at lower costs. Of particular interest to the chemical industry, as soon as a few more development problems are ironed out, is the possibility of making stainless steels with lower carbon content than are now available.

Present steel industry practice calls for the tedious adjustment of the chemical composition of the steel while it is in the molten state, depending on end use. But these specially compounded steels are often hard to roll. The new development paves the way for the making of only a few grades of easily rolled steels, with final chemical adjustment coming during annealing. Underlining the rapid industry acceptance of this principle, 18 gas alloying installations are either in operation or under order by steel companies.

In the open-coil process, nylon cord or corrugated steel strip is inserted as the steel sheet is being rolled prior to annealing. After the nylon is removed, the "open coil" is lifted by a magnetic hoist (see photo) into the annealing furnace where hot gases are blown through the coil, providing uniform heating. Besides making the steel surface available for chemical alteration, the open coil slashes the time needed for annealing, since the whole roll can be heated and cooled in much less time than conventional processes.

Type of gas used during annealing depends on what chemical changes are desired. Moist hydrogen, for example, is used when carbon is to be removed. With this technique, carbon and nitrogen can be reduced to levels where they can't be detected by normal means. Lowest level that had been possible up to now was about 0.06% carbon and 0.003% nitrogen.

Special Tank Cars Ship HCl

American Chemical's new chlorinated hydrocarbons plant at Watson, Calif., is now receiving anhydrous HCl by railroad tank car—an innovation that could have a major impact on the use of this chemical, a waste product in many locations.

Most big consumers of HCl either get their supply from on-site chlorination operations or are supplied by pipeline from nearby plants for the simple reason that HCl is so cheap that it usually doesn't pay to ship it. Secret of the success of American Chemical's operation is the development, with General American Transportation Corp., of a special tank car that can handle liquid HCl in large quantities.

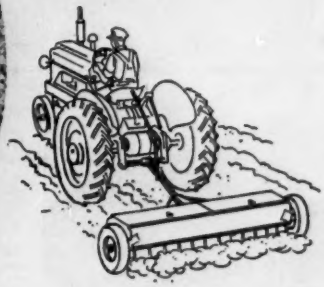
American Chemical was forced to play the role of reluctant innovator at Watson because the supply of HCl available is not sufficient for the firm's slated production of ethyl chloride. American has some on-site HCl available from the cracking of ethylene dichloride in the making of vinyl chloride; some more HCl comes via pipeline from parent Stauffer's Dominguez facility, about a mile away. But this still leaves American with an HCl deficit that must be made up by transporting the acid several hundred miles.

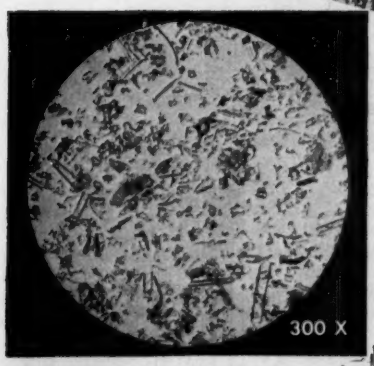
The special 12,000-gal. tank cars used for this purpose are constructed of ⅝-in. steel with 10-in. insulation to keep the temperature of the liquid HCl between −50 and 0 F. for 30 days.

These cars are designed for a working pressure of 600 psi., are equipped with liquid CO_2 cylinders that vent through two extra domes in the top of the car. As the temperature of the liquid HCl inside the car starts to rise, some of the CO_2 in the cylinders is automatically allowed to vaporize, dropping the temperature down to the desired level. Other handling techniques are similar to the precautions taken with liquid chlorine.

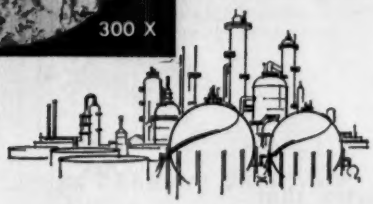
Under temporary Interstate Commerce Commission regulations, each tank car shipment is monitored by a technician who accompanies the car to check the pressure gage. As experience proves the reliability of the automatic devices, it is hoped the monitor can eventually be eliminated.

For fertilizer coating—Celite 379, a natural milled diatomite, provides the uniform conditioning needed to prevent caking of granular, mixed or prilled fertilizers—maintains good free-flow characteristics even after prolonged storage.

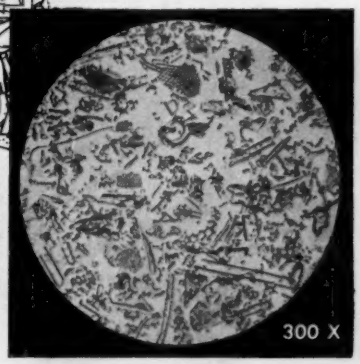




For catalyst carriers—Super Floss, finest particle size flux-calcined Celite grade, is used where a non-reactive porous silica support is needed. (Also available: special Celite supports in many preformed shapes for strength, high temperature stability, resistance to abrasion and attrition.)



As a paint-flatting agent—Celite 281, air-floated fines of flux-calcined diatomite, provides uniform and efficient flatting at low cost. Contributes to control of low angular sheen, durability, and faster drying.



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Celite diatomite absorbs its own weight of liquid . . . yet stays 'dry'

No matter which of the many available grades you choose, you can depend on a given volume of inert Celite* to retain its typical dry-powder characteristics even after absorbing its own weight of liquid.

Actually, Celite can absorb a total of more than twice its own weight. That's because a mass of the fine skeletal particles is approximately 93% air space or voids. Yet, in spite of this very high porosity, Celite is essentially non-hygroscopic.

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For technical data on specific mineral filler or filtration problems, talk to your nearby Celite engineer. Or write to Johns-Manville, Box 14, New York 16, N. Y. In Canada, Port Credit, Ontario.

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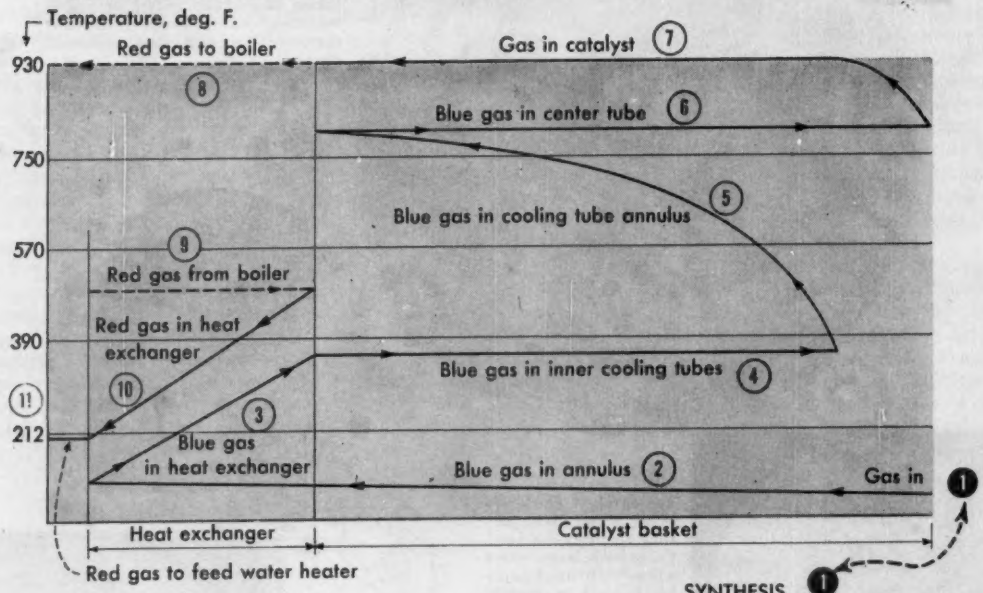
Gas Temperature Pattern of Ammonia Converter Modified for Steam Generation



Cools Catalyst Bed— Generates Steam, Too

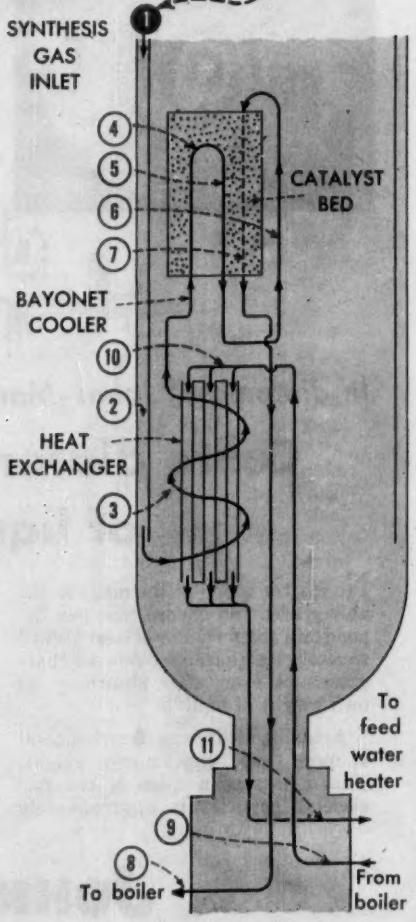
Multi-benefits result from ammonia converter that utilizes sensible heat from exit gas to 'fire' boiler.

How can you cool an exothermic catalytic reaction, maintain optimum catalyst temperature and generate high-pressure steam at the same time—without using a heat-transfer fluid? This problem has been solved by the new ammonia synthesis converter design of Chemical Construction Corp., New York.

Although the temperature level in ammonia synthesis (about 930 F.) is generally considered too low for economical heat recovery, there are special cases where such is desirable. Chemico, for example, is now building a 250-ton/day ammonia plant in France for Aquitaine-Chimie incorporating the new converter design.

Need for additional in-plant steam in this case made it economical to recover the heat from the ammonia unit. Too, in energy-poor countries such as Japan, recovering every Btu. of process heat is practically mandatory and, in order to compete successfully, process designers must be able to give an exact heat accounting.

Chemico's unique method of using cool incoming N_2-H_2 synthesis gas to keep the catalyst bed at optimum temperature level has already been described (*Chem. Eng.*, May 18, 1959, p. 72). The new heat-recovery system is integrated into that basic design.



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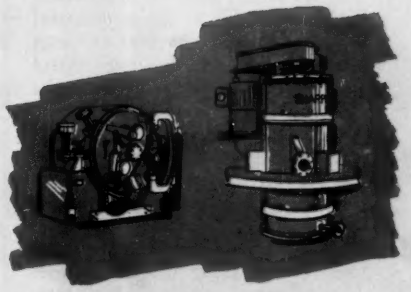

In many plants today, pressurized models of the Super-D-Hydrator are proving the big difference in deliquifying and multiple washing of such high purity materials as the polyolefins. In addition, the vertical P-4000 puts all of the high performances of the Super-D-Canter at your control . . . plus operation in a pressurized system.

These two centrifuges are pacing the chemical industry with innovations that are tuned to advanced processing systems.

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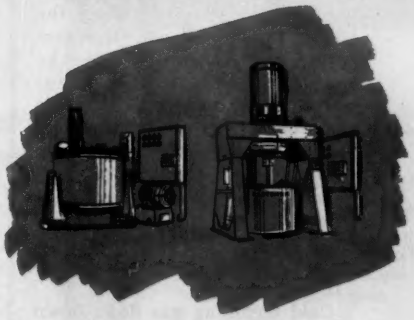

Boric acid, sodium sesquicarbonate, aspirin . . . typical of the crystals that often must be "babied" as they are deliquified and rinsed to high purity in Fletcher automatic batch type centrifuges . . . with complete control of process variations. Two types with wide choice of drives, speed ranges, and basket capacities from 1 to 16 cu./ft. The new Fletchers are leading the way with outstanding performance and tonnage production.

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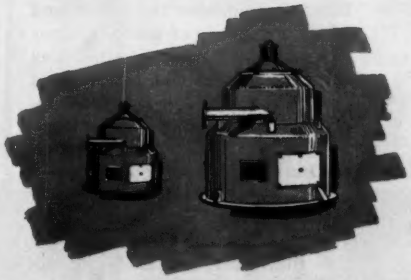

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A wide range of controllable variables assures process flexibility which marks this Sharples centrifuge as a natural for many types of solids which are otherwise difficult to process efficiently.

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► **Simple in Principle**—The new unit simply takes exit gas (red gas) from the catalyst bed at about 930 F. and passes it through a steam boiler. After cooling to about 500 F., red gas returns to the high-pressure enclosure where it gives up still more heat to incoming synthesis gas (blue gas).

Main problem that engineers encountered was incorporating this basic idea in the mechanical design of the converter without upsetting the cooling-control functions already inherent in the reactor system.

Other heat-recovering ammonia converters use pressurized water circulating through coils in the catalyst bed to transfer heat to the boiler. Chemico claims that type system requires extra regulating valves and presents many additional maintenance problems. And when the boiler is shut down, the ammonia converter must also be shut down. With a liberal-sized water cooler, however, Chemico's new design permits ammonia production even when the steam boiler is down for repairs.

► **Tracing Gas Flow**—Path that incoming gas takes in flowing through the converter can be traced on the temperature profile chart above.

Cold incoming gas flows down through the annulus between the high-pressure closure and the internals. It enters the lower end of the shell side of an exchanger where it is heated against gas returning from the boiler. Gas then flows up through the special bayonet coolers (described in the earlier article) which maintain catalyst bed at about 930 F. throughout.

From the catalyst bed, the hot (930 F.) product gas flows out of the high-pressure shell to the steam boiler. After cooling to about 500 F., product gas returns to the converter where it flows through the tubes of the heat exchanger to warm the incoming blue gas. Red gas, now about 200 F., then flows from the converter to a boiler feedwater preheater.

► **Control Is the Key**—When the Chemico converter is used in conjunction with a high-pressure steam boiler, control of catalyst bed temperature is regulated by controlling temperature of gas returning to converter from the boiler.

Control is by a single three-way valve operating a bypass around the boiler. Motor regulating this valve is actuated by a temperature scanning device on control panel. This scanner checks the temperature reading of 24 thermocouples set at different levels in the catalyst bed against a preset value.

If scanner finds any thermocouple reading exceeds the desired value, bypass valve is changed to send more gas through the boiler, resulting in a colder gas returning to the converter. This gas, in turn, imparts less preheat to the incoming synthesis gas, which causes a greater cooling of the catalyst bed, bringing the temperature back in line.

Conversely, if any thermocouple reading is less than the preset value, valve passes less gas through the boiler, thereby providing less cooling of the catalyst bed.

► **Standby Control System**—To provide optimum catalyst temperature control during boiler shutdowns, a second automatically operated three-way valve is provided. This valve is actuated by the temperature scanner in the same fashion as the boiler bypass. When catalyst gets too hot, the valve diverts some of the incoming cold synthesis gas directly to the catalyst bed, providing more cooling.

► **How Much Steam?**—Amount of heat that can be recovered per pound of ammonia produced depends on how the converter is operated.

For example, with a 30% conversion rate, it is possible to generate 0.975 lb. of 140-psig. steam per pound of ammonia produced. This assumes that boiler feedwater is preheated from 75 to 195 F., that there is a 10% blowdown from the boiler and that there are no heat losses to the atmosphere.

Steam can also be generated at higher pressure if desired. At a conversion rate of 33.6% (quite high), the unit could produce about one pound of 260-psig. steam per pound of ammonia, making the same assumptions as above.

Engineers Win Benefits Via One-Week Strike

In a bellicose atmosphere, marked by the arrest of six pickets and union charges of police violence, about 2,400 unionized engineers and scientists resorted to a one-week strike last month to secure better working conditions.

The Assn. of Professional Engineering Personnel (affiliated with Engineers and Scientists of America) threw up picket lines around five Radio Corp. of America plants in the Philadelphia area, after breaking off a two-month contract negotiation with RCA management. Talks had stalled over questions of pay rise, a merit plan and job seniority. Settlement was reached only with the aid of Commissioner John Murray of Federal Mediation and Conciliation Services.

This is the second time in recent history that the militant, and growing, APEP has struck RCA. The union pulled its then 1,800 members out on strike for two weeks in 1958 (*Chem. Eng.*, Oct. 6, 1958, p. 156).

New one-year contract to come out of last month's strike includes a 4½% across-the-board pay increase for RCA's professional employees who currently are earning $6,000-20,000/yr. Initially, APEP had asked for 6%; company had offered 3½%. Also included in the settlement is a new merit plan that, unlike previous plans, cannot be altered unilaterally by the company. The plan is now frozen until Oct. 1, 1961. Thereafter, RCA must give the union at least 90 days notice of any desire to change the plan, during which time union and company will negotiate proposed changes. Moreover, the new contract provides for an involved point-system seniority plan, which APEP describes as giving professional employees a greater degree of job security. Other aspects of the strike-born settlement include increase in patent payments to inventors from $150 to $200, as well as agreements on pension plan, employee attendance at professional society meetings, employee insurance while traveling on company business, grievance procedures.

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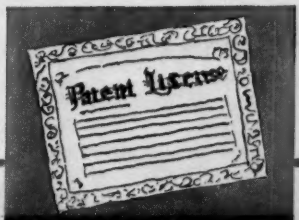

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Well, perhaps there's a little more to your gaining use of Becco patents than just mailing your dollar in, but not much more. And certainly, no more money. The $1.00 really does cover it.

Becco has lots of patents, granted as a result of innovations in the use of Hydrogen Peroxide and other Peroxygen chemicals developed in Becco's Research Laboratories. But they don't do us a whole lot of good locked tightly in our safe. So, we long ago adopted the following policy:

If one of our patents can help you, we'll be glad to license the rights to you **perpetually,** for just one dollar. You get a nice certificate, incidentally, to cover the legalities, but more important — you also get free our complete engineering help in setting up your process, handling the material, maintenance, etc., etc.

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Please send your list of patents available on the use of
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Please tell me more about your Four-Fold Engineering Service.

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Russia Stresses Plastics But Still Trails West

Although the Russians continue to trail the Western world by a wide margin in plastics technology, they have begun laying the groundwork for some very promising future advancement in the field.

This is the general consensus of the some 20 American scientists and engineers who attended the International Symposium on Macromolecular Chemistry held in Moscow last month. Meeting gathered over 1,200 polymer experts from 25 countries to listen to more than 160 technical papers and to tour various Soviet plastics research and production facilities. Among the Americans who attended were representatives of such organizations as Esso, Du Pont, Eastman Kodak, General Electric, Brooklyn Polytechnic and Mellon Institute.

According to these observers, research and development work in plastics and polymer technology has become one of the top-priority fields in the Soviet Union during the past two to three years. Long concentrating most of their "materials development" effort on steel and other metals, the Russians now are attempting to "leapfrog" the West in plastics. Moreover, they seem anxious to avoid freezing industrial development of plastics in any particular area since they recognize how quickly even the newest polymers become outmoded.

At the moment, most commercial work in the U.S.S.R. admittedly borrows heavily from Western, and especially American, plastics technology. But, observers stress, the Russians have launched major research projects in a number of relatively new and unexplored areas. Among those that most impressed Westerners at the Moscow meeting were reports on Soviet investigations of radiation polymerization, inorganic polymers and polymers with semiccnductor properties (*Chementator*, Jan. 25, p. 50). One major problem that the Soviets face, however, is getting their promising research work out of the laboratory and into commercial producing facilities.

INDUSTRY NEWS

NEW TERMINAL supplies weighted water for oil well drillers.

Dow Chemical Co.'s Dowell Div. recently put into service the above "weighted water" terminal on Berwick Bay near Morgan City, La. It handles water solutions of calcium chloride, known as Heavi-water, which are sold for use as weighting material in oil well completions. The terminal receives calcium chloride pellets by tank car from a Dow plant in Michigan, dissolves them in water—inside the tank car—to make up a stock solution having a density around 11.4 lb./gal. (*Chem. Eng.*, Feb. 10, 1958, p. 80.) The solution is led to storage tanks. It can be concentrated with additional calcium chloride or diluted with water to meet a customer's density requirements. Upper density limit with calcium cholride is about 11.7 lb./gal., but the terminal can reach 14 lb./gal. by adding zinc chloride. Product is shipped by truck or barge to the well site. Its advantage to drillers is that it duplicates the density of mud commonly used in drilling operations but is a true solution with no solids in suspension.

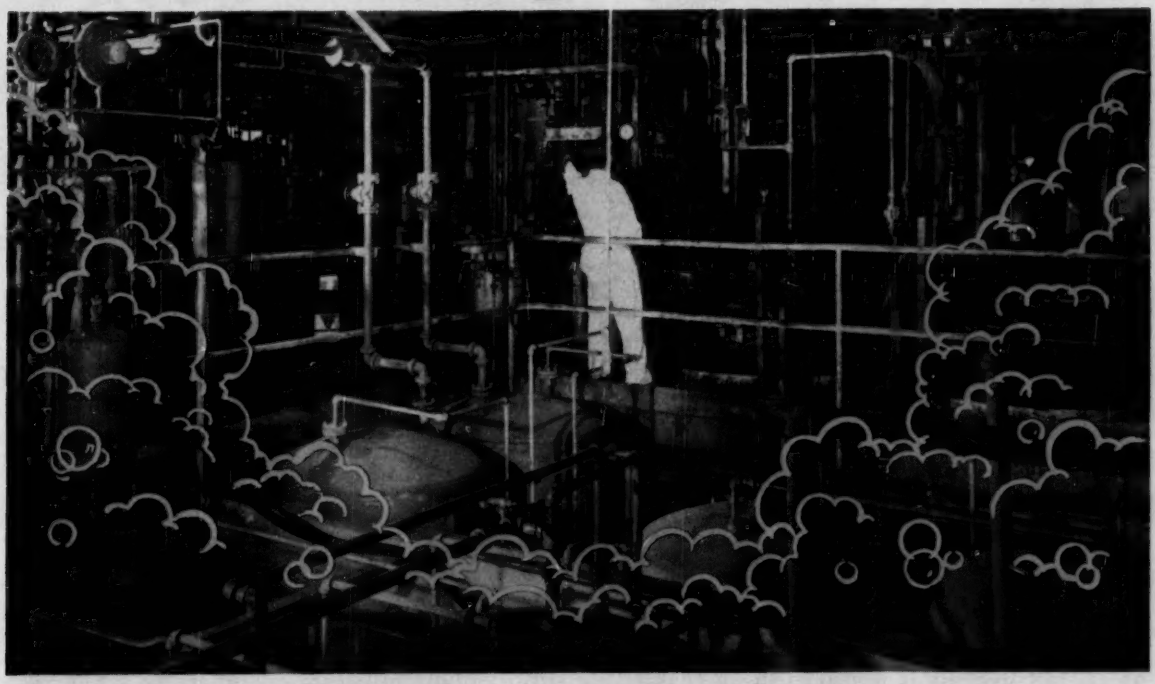
American Rubber & Chemical Co. is the name of a new firm formed jointly by Stauffer Chemical Co. and American Synthetic Rubber Co. It will build a multimillion-dollar plant at Louisville, Ky., to produce polybutadiene and polyisoprene synthetic rubbers. Initial plant capacity will be 30,000 long tons/yr., but the design will provide for a future increase to 50,000 long tons/yr. with minor modifications. Completion of the plant is scheduled for September, 1961. It will use processes owned by Phillips Petroleum Co. Stauffer and American Synthetic Rubber each own 50% of the new company.

Allied Chemical Corp. is beginning construction on a new multimillion-dollar polyethy-

Industry News continues on page 168.

SILICONE NEWS from Dow Corning

Foam Eating Into Profits?



Job-proved Dow Corning Defoamers Speed Processing, Raise Capacity

Ever try to blow up a balloon with a hole in it? Hard to get it up to any size, isn't it. The same's true of foamers . . . with Dow Corning Silicones added. Silicones put holes in bubbles . . . keep systems foam-free! They're perfect foam controllers: reliable, economical, safe, easy to use . . . quickly available from Dow Corning warehouses conveniently located to expedite shipment to you.

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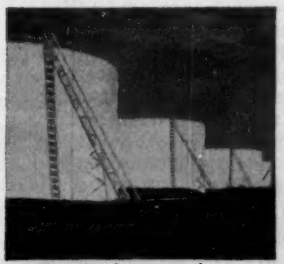

Eliminate foam-overs here.

What's Your Foamer? Today, Dow Corning Silicones are used both as antifoamers and as defoamers in processing chemicals, petroleum products, asphalt, textiles, paper, paints, adhesives . . . in metalworking and laboratory work . . . in virtually every industry and process — even in food processing where the use of Dow Corning Silicones at designated levels is sanctioned by FDA.

If you're troubled with foam slowing down your plant operation, taking up productive capacity, or creating maintenance, it'll pay you to test Dow Corning Silicones.

New Literature and Free Sample. A new 8-page manual, "The ABC's of Defoaming", will help you learn all the facts about Dow Corning silicone defoamers . . . how and where to use them, examples of the small quantities of silicones needed to control foam, and typical successful applications. Write today for your FREE copy and ask for a generous FREE SAMPLE of the silicone defoamer that you can test . . . that will likely give you the most efficient, most economical defoaming action. Indicate your type of foamer: aqueous, oil, food or other. Address Dept. 1808.

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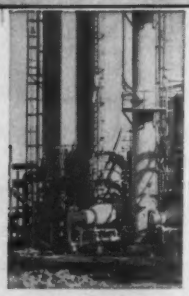

Lineup for the Series

1. Petrochemicals Map Their Mature Years, May 30, p. 54
2. Chemicals From Methane, June 27, p. 74
3. Ethylene Copes With Growing Competition
4. Propylene and Butylene Chemicals
5. Aromatics

Petrochemicals 3

Ethylene Copes With Growing Competition

Ethylene is maintaining a reasonable supply-demand balance, though the picture suffers from lack of vitality caused by lack of new markets and derivatives, threats to growth of certain older markets.

Richard F. Messing and James W. Bradley, Arthur D. Little, Inc.*

Ethylene, largest-volume aliphatic petrochemical raw material, is in reasonable demand-supply balance currently, although the outlook for two derivatives, ethylene oxide and ethyl chloride is somewhat clouded. The bright spot in the outlook is the rapidly growing demand for polyethylene.

▶ **Demand**—No major new ethylene-consuming chemicals have been commercialized that will materially affect the demand outlook. In fact, the only new use of any real interest is the process now being commercialized by Continental Oil to produce long chain alcohols, some of them similar to that manufactured by the Aldol and Oxo processes.†

Future growth of ethylene will be more dependent on polyethylene and vinyl chloride resins than on other derivatives.

▶ **Supply**—Ethylene capacity, including that under construction but excluding that announced, is approaching 5.8 billion lb./yr., which is 23% greater than estimated 1959 demand of 4.76 billion. Consumption in 1950 was 1.33 billion lb.; average growth rate over the 1950-59 period has been 15.1%/yr.

As ethylene capacity continues to grow, we expect to see an extension of the trend toward merchant production, or more joint ventures between ethylene consumers and producers. Merchant suppliers, including capacity under construction but not that planned, now represent 30% of total capacity.

Recent plants have emphasized the production of ethylene at petroleum refineries rather than production from natural gas liquids at a pipeline site distant from producing areas. New additional capacity in the major market centers of ethylene derivatives will be from refineries. Future capacity based on natural gas will be concentrated in the natural gas producing areas.

▶ **More Merchant Producers**—A few years ago, merchant ethylene was available in quantity for new ethylene chemical ventures only on the Gulf. Now, major plants exist on the West Coast, in the Midwest, and on the East Coast. Refiners and natural gas utilities are trying to promote additional ethylene consuming complexes in all these areas.

As ethylene production know-how has become widely available, and as more merchant producers have entered the field, competitive pressures have tended to put a ceiling on ethylene prices,

*For authors' biographies, see *Chem. Eng.*, May 30, 1960, p. 54.

†A 50-million-lb./yr. plant is under construction. Major markets for Conoco's Alfol alcohols are expected to be in detergents, shampoos, plasticizers.

CELANESE TRIMETHYLOLPROPANE

adds outstanding protection, durability and color retention to alkyd paints

Here's how to improve alkyd paint quality without increasing cost. Paint formulations made with trimethylolpropane based resins withstand outdoor exposure and weather . . . adhere strongly . . . resist alkalis and detergents.

They impart hardness, impact resistance, and color retention on overbake or aging, to a greater degree than conventional alkyds. Dry and baking times are reduced, too.

Thus, in highly competitive fields, such as appliance and automotive, trimethylolpropane based resins provide marked competitive advantages.

Celanese Trimethylolpropane is promptly available in any quantity, at a price that's competitive. It is shipped in protective, multi-wall, polyethylene-coated aluminum foil-lined heat-sealed bags.

For complete data on how trimethylolpropane can improve paints, please write to: Celanese Chemical Company, Dept. 553-H, 180 Madison Avenue, New York 16. Celanese®

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Celanese CHEMICALS

Best Hopes for Ethylene Growth: Polyethylene, PVC

Estimated Ethylene Capacity

(Million Pounds)

Producers & Location	Capacity[2]	Producers & Location	Capacity[2]
Allied Chemical		Odessa Styrene	
Tonawanda, N. Y.	30	Odessa, Tex.	15
American Chemical		Olin Mathieson Chemical	
Watson, Calif.	80	Brandenburg, Ky.	100
Columbia Gas[1]		Petroleum Chemicals[1]	
Siloam, Ky.	200 (pl.)	Lake Charles, La.	200
Dow Chemical		Phillips Chemical[1]	
Bay City, Michigan	35	Sweeny, Tex.	290 (inc. 35 u.c.)
Plaquemine, La.	85	Rexall Drug-El Paso Natural Gas	
Freeport & Velasco, Tex.	470	Odessa, Tex.	200 (pl.)
Midland, Mich.	150	Shell Chemical	
Du Pont		Houston, Tex.	150
Orange, Tex.	70	Torrance, Calif.	45
Gulf Oil Corp.[1]		Standard Oil of New Jersey[1]	
Port Arthur, Tex.	425	Bayway, N. J.	150
Humble Oil Co.[1]		Baton Rouge, La.	300
Baytown, Tex.	80	Texas Eastman	
Jefferson Chemical		Longview, Tex.	175
Port Neches, Tex.	250	Union Carbide	
Koppers		Institute & S. Charleston, W. Va.	545
Kobuta, Pa.	25	Seadrift & Texas City, Tex.	795
Mobil Oil[1]		Torrance, Calif.	120
Beaumont, Tex.	380 (u.c.)	Whiting, Ind.	250
Monsanto Chemical		Ponce, Puerto Rico	110
Texas City, Tex.	175	Wyandotte Chemicals	
U. S. Industrial Chemicals		Wyandotte, Mich.	30
Tuscola, Ill.	330	Total including u.c. & pl.	6,260

1. Merchant suppliers. 2. u. c. = under construction; pl. = planned.

Estimated Ethylene End-Use Breakdown

(Million Pounds)

End Use	1959	End Use	1959
Ethylene oxide	1,431	Ethylene dichloride	244
Polyethylene	1,250	Ethyl chloride[2]	265
Synthetic ethyl alcohol	975[3]	Ethylene dibromide & Misc.	90
Styrene monomer[1]	499		4,754

1. Includes small quantities not produced from ethylene. 2. Includes that made from ethyl alcohol. 3. Fiscal 1959.

which are now about 5¢/lb. on the Gulf Coast. The result has been a trend on the part of chemical consumers of ethylene to buy rather than produce ethylene themselves. Also some chemical companies are discouraged by the fact that dehydrogenation of ethane to ethylene is not as familiar an operation as chemical synthesis steps such as chlorination, polymerization.

Ethylene manufacture is, however, closely related to refining and petroleum companies are anxious to participate in petrochemicals. Encouraging petroleum companies to choose ethylene as their initial step to diversification into petrochemicals: easy access to technology, fair growth prospects, ability to contract output without setting up chemical sales organizations, likelihood of later upgrading.

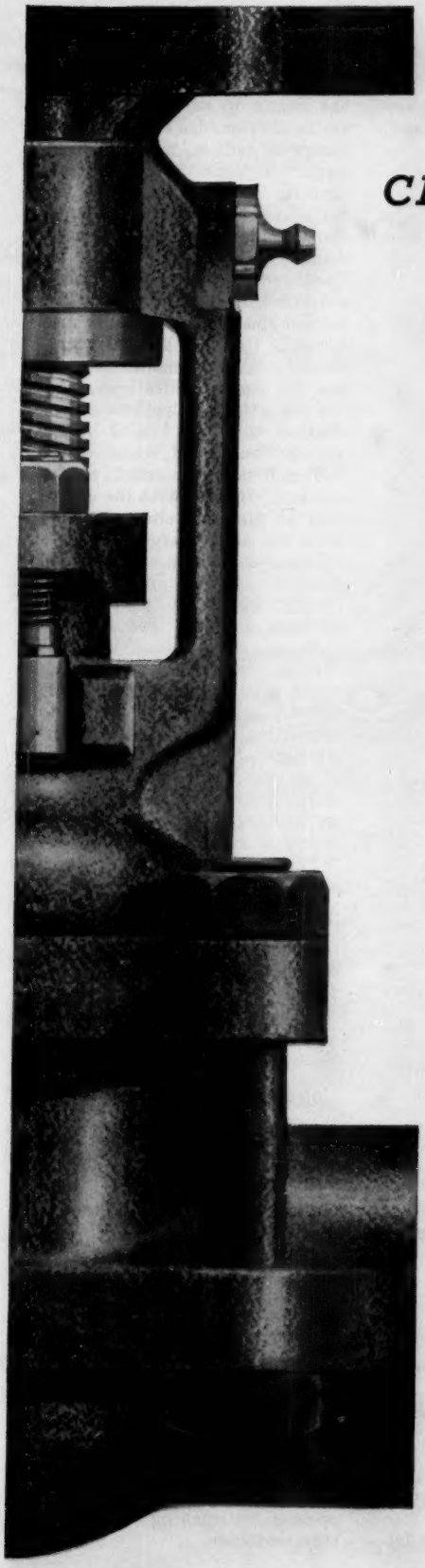
▶**Refinery Gas Grows**—There are only two major units producing ethylene at a pipeline site distant from a producing area: Olin-Mathieson at Brandenburg, Ky.; U. S. Industrial Chemicals at Tuscola, Ill. It has become increasingly difficult to justify economically the manufacture of ethylene from typically stripped natural gas. Sufficient quantities of ethane and higher hydrocarbons must remain or be put back in the line to maintain Btu. content, and extraction for a minimum-sized ethylene plant is not always feasible without reducing the Btu. content below required minimum. Furthermore, pipeline companies in many cases do not have the degree of control over the composition of the natural gas in their line to effectively guarantee ethane contents.

The rising price of natural gas (contracts in producing areas are now being written above 20¢/1,000 cu. ft.) and ethane's Btu. value in the line vs. a relatively stable price picture for refinery ethylene tends to push the economics in favor of refinery ethylene or ethylene produced from ethane and higher liquids stripped at or near the wellhead. Some utilities with control over their own production and others in special circumstances may well enter into ethylene production. But most added production will be at refineries or from natural gas near producing areas.

Petrochemicals 3

Polyethylene Forecast Continues Bright

Polyethylene has been the most rapidly growing ethylene end use and in 1959 was second in importance only to ethylene oxide. Polyethylene's rapid growth will increase its importance over other derivatives. Production has jumped from less than 100 million lb. in 1951 to about 1.2 billion in 1959. High-pressure (conventional) polyethylene in 1959 amounted to about 1.1 billion lb. versus 100 million for linear (low-pressure) polyethylene. *(Continued)*



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DEPENDABILITY is the *first* consideration when you choose a valve, because the cost of valve failure in down time is almost always greater than the cost of the valve itself. That's why so many of the best distributors sell the OIC line. They know that when they recommend OIC valves, their customers can depend upon them...even in those tough problem installations. Equally important is the distributor's own dependability...his capacity to deliver the valves you need, when you need them. Here, OIC offers the support of a complete factory inventory of bronze, iron, ductile iron, cast and forged-steel valves. You get immediate delivery from your OIC distributor's representative stock, and 4 to 5-day delivery from warehouse or factory. For dependability of product and service, phone your OIC distributor. He has our all-out support in serving you.

OIC VALVES

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Markets for linear polyethylene were a severe disappointment to the industry last year. But in recent months, demand has begun to surge because of use in blow-molded items such as detergent bottles, where a rigid container is desired but where capacity is not critical. Molded household goods and pipe have also accounted for some increased demand. There seems to be no likelihood, however, that linear polyethylene will catch up in market size to high-pressure material in the next several years. Stress cracking remains a problem for many applications.

Conventional polyethylene production in 1959 totaled about 1.10 billion lb., of which about 300 million represented export markets. In fact, with the exception of film and sheet, exports were the single largest identifiable end use. Both capacity and demand abroad are growing rapidly, but the net effect will probably be some reduction in U. S. export volume.

Film for packaging of fresh produce, other grocery products and dry goods has continued to demonstrate surprising market strength. Nearly three-quarters of all film is now made by resin manufacturers, who regard it as an important means of sustaining resin volume.

Polyethylene, like polypropylene, must compete for markets against other polymers. Projections for the near doubling of polyethylene markets made by some in the industry will require future price levels well below those currently quoted, 32½¢/lb. for conventional and 35¢/lb. for linear material. The present overcapacity, the addition of new producers who must find markets, plus the intentions of two consumers of polyethylene, Rexall Drug (in conjunction with El Paso Natural Gas) and Foster-Grant, to enter into polyethylene production will intensify competitive pressures.

Polyethylene Film Flourishes, Linear Lags

Estimated Polyethylene Capacity

(Million Pounds)

Producer & Location	Capacity[2]	Type[3]
Allied Chemical		
Tonawanda, N.Y.	80 (partly u.c. & pl.)	30 C & low mol. wt.
Orange, Tex.		50 L
Celanese		
Houston, Tex.	50	L
Dow Chemical		
Bay City, Mich.	160 (partly u.c.)	100 C
Plaquemine, La.		60 L
Freeport, Tex.		
Du Pont		
Orange, Tex.	300 (partly u.c.)	260 C
Victoria, Tex.		40 L
Foster Grant		
Baton Rouge, La.	20 (pl.)	C
Goodrich-Gulf		
Port Neches, Tex.	13 (u.c.)	L
W. R. Grace		
Baton Rouge, La.	50	L
Hercules Powder		
Parlin, N.J.	60[1]	L
Lake Charles, La.	60[1] (u.c.)	L
Koppers		
Port Arthur, Tex.	50	40 C
Port Reading, N.J.		10 L
Monsanto Chemical		
Texas City, Tex.	100 (partly u.c.)	C
U.S. Industrial Chemicals		
Tuscola, Ill.	100	C
Houston, Tex.	200 (partly u.c.)	C
Phillips Chemical		
Pasadena, Tex.	75	L
Rexal Drug & Chemical		
Odessa, Tex.	150 (pl.)[1]	C & L
Spencer Chemical		
Orange, Tex.	135 (partly u.c.)	C
Texas Eastman		
Longview, Tex.	100	C & low mol. wt.
Union Carbide		
S. Charleston & Institute, W.Va.	625 (partly u.c.)	570 C
Texas City, Tex.		55 L
Seadrift, Tex.		
Torrance, Calif.		
Whiting, Ind.		
Total capacity (inc. u.c. & pl.)		
Conventional	1,805	
Linear	523	
Total	2,328	

1. Includes linear and polypropylene capacity. 2. u. c. = under construction; pl. = planned. 3. C = conventional; L = linear; mol. wt. = molecular weight.

Estimated Polyethylene End-Use Breakdown

(Million Pounds)

End Use	1959 Conventional	1959 Linear	1959 Total[1]
Film & sheet	320	7	327
Injection molding	170	42	212
Wire & cable insulation	105	1	106
Blow molding	38	8	46
Pipe	62	11	73
Coatings	50	small	50
Exports	300	22	322
Other	55	9	64
	1,100	100	1,200

1. Based on U. S. Tariff Commission Reports.

Petrochemicals 3

Vinyl Chloride Market Offers Growing Room

Ethylene dichloride (EDC) is produced by the chlorination of ethylene. EDC's major outlet, 78% of estimated 1959 production of 885 million lb. was for vinyl chloride monomer. The pyrolysis of ethylene dichloride yields vinyl chloride monomer and hydrochloric acid.

Profitable disposal of the latter product has been one of the principal restrictions in the growth of the ethylene dichloride process for making vinyl chloride monomer.

Introducing—

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Petro-chemical users will cash in on its unsurpassed oil- and chemical-resistance – inside and out. In fact, that's important to any user of the newest fire-fighting chemicals. And D-500 Fire Hose is available with white, black, yellow or red cover for ready visibility as well as for those who require color-coded fire-fighting lines.

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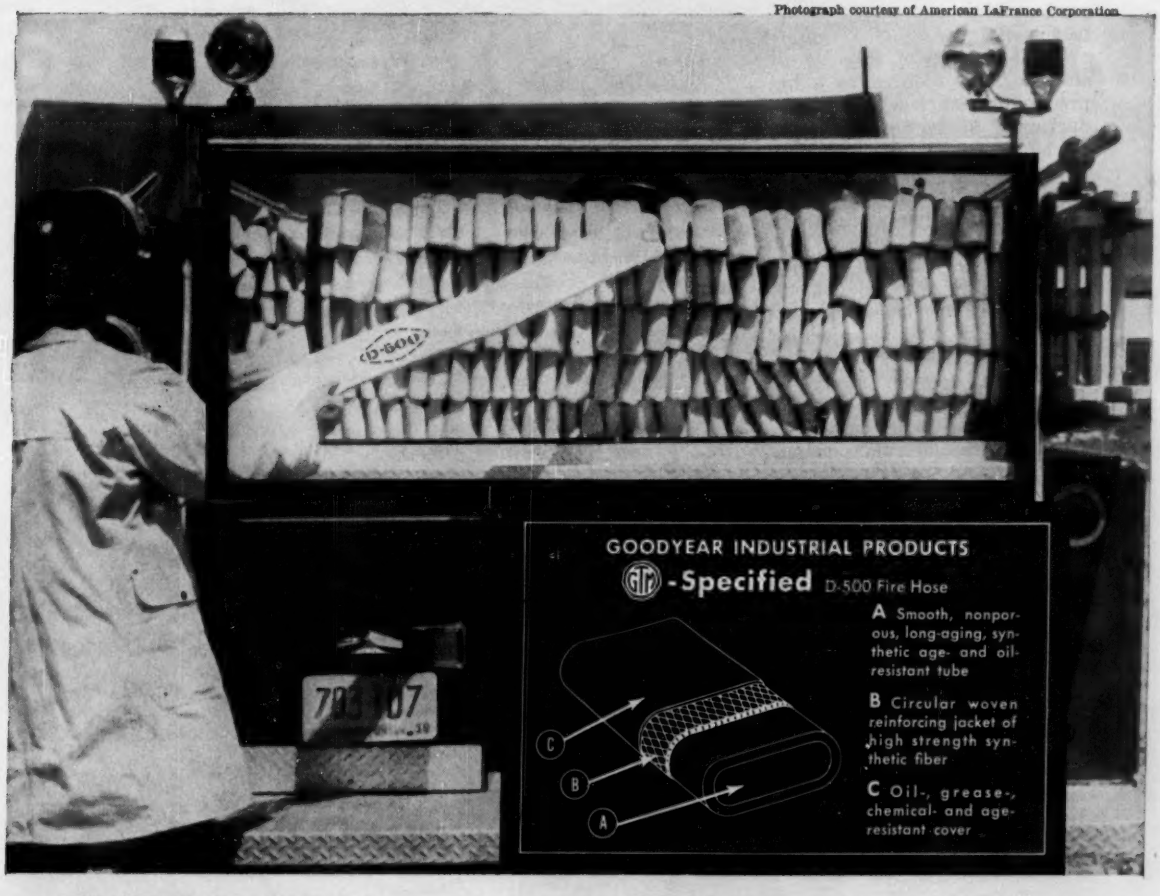
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C
B
A

INDUSTRIAL FIRE HOSE BY

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THE GREATEST NAME IN RUBBER

The acetylene process which is now estimated to account for 55% of vinyl chloride monomer production synthesizes the monomer by the addition of hydrochloric acid to acetylene. In spite of the higher cost of acetylene (11 to 13¢/lb. vs. 5¢/lb. for ethylene), the lack of market for byproduct acid in many areas frequently favors this process which does not involve ethylene dichloride as an intermediate. Chlorine balance has been achieved in a number of recent plants by the use of a combined process where ethylene dichloride is pyrolyzed to vinyl chloride monomer and hydrochloric acid; the hydrochloric acid is then reacted with acetylene to produce additional vinyl chloride monomer.

Small amounts of ethylene dichloride are produced as a byproduct of ethylene oxide production if production is by way of the chlorohydrin route.

Too late for inclusion in the table of ethylene dichloride capacity, right, Columbia-Southern announced it is installing 100 million lb./yr. at Lake Charles.

Essentially all vinyl chloride monomer is converted to polyvinyl chloride. The category of Polyvinylchloride resins also includes some copolymers that contain small quantities of other monomers, primarily vinyl acetate. Polyvinylchloride consumption has been growing close to 10% a year since 1951.

About 15% of ethylene dichloride production enters the gasoline market, where it serves as a tetraethyl lead scavenger; that is, forms combustible lead compounds upon the burning of gasoline.

Ethylene dibromide is more effective as a scavenger but more costly. In automotive and truck fuel, ethylene dichloride and ethylene dibromide are usually used in just about equal proportions.

PVC Use Grows 10%/Yr., Takes Most Monomer, EDC

Estimated Ethylene Dichloride Capacity

(Million Pounds)

Producer & Location	Capacity	Producer & Location	Capacity
American Chemical		Jefferson Chemical	
Watson, Calif.	40	Port Neches, Tex.	15
Diamond Alkali		Monsanto Chemical	
Houston, Tex.	80	Texas City, Tex.	85
Dow Chemical		Olin Mathieson	
Freeport, Tex.	100 (33[1])	Brandenburg, Ky.	50 (est. 15[1])
Plaquemine, La.	100 (9[1])	Union Carbide	
Midland, Mich.	small	Charleston, W. Va.	85
Ethyl Corp.		Texas City, Tex.	100
Baton Rouge, La.	180	Wyandotte Chemical	
Houston, Tex.	80	Wyandotte, Mich.	5[1]
			920

1. Represents byproduct capacity of chlorohydrin-process ethylene oxide plants; these may be converted to propylene oxide-glycol which will not yield byproduct ethylene dichloride.

Estimated Ethylene Dichloride End-Use Breakdown

(Million Pounds)

End Use	1959	End Use	1959
Vinyl chloride	680	Other	77
TEL scavenger	128		885

Estimated Vinyl Chloride Resin End-Use Pattern

(Million Pounds)

End Use	1959[1]	End Use	1959
Film, sheet & coated fabrics	212	Protective coatings	31
Molding & extrusion	305	Misc.	95
Flooring	152		860
Textile & paper treating & coating	65		

1. Based on U. S. Tariff Commission Reports.

Estimated Vinyl Chloride Monomer Capacity

(Million Pounds)

Producer & Location	Capacity[2]	Process	Producer & Location	Capacity[2]	Process
Allied Chemical			Niagara Falls, N.Y.	20	Acetylene
Moundsville, W.Va.	100	Acetylene	Goodyear Tire		
Diamond Alkali			Niagara Falls, N.Y.	45	Acetylene
Houston, Tex.	50	Acetylene	U. S. Rubber		
Dow Chemical			Painesville, Ohio	60	Acetylene
Freeport, Tex.	80	Combined	Union Carbide		
Plaquemine, La.	60[1]	Ethylene	Texas City, Tex.	100	Combined
Ethyl Corp.			S. Charleston, W.Va.	150	Combined
Baton Rouge, La.	60	Ethylene	Monsanto Chemical		
Houston, Tex.	50 (u.c.)	Ethylene	Texas City, Tex.	100	Combined
General Tire & Rubber			American Chemical		
Ashtabula, Ohio	25	Acetylene	Watson, Calif.	25	Ethylene
B. F. Goodrich			Cumberland Chemical		
Calvert City, Ky.	70	Combined	(Airco-Mastic)	50 (u.c.)	Acetylene
Louisville, Ky.	100	Acetylene		1,645	

1. Additional capacity is planned for 1960. 2. u. c. = under construction.

Petrochemicals 3

More Threats Ahead for Ethylene Oxide

In terms of pounds of ethylene consumed, ethylene oxide is still the most important of the ethylene-based chemicals. The older chlorohydrin process for ethylene oxide is now considered uneconomic for new plants except under special circumstances of chlorine availability. All recent units, except that of Dow Chemical, have involved the direct oxidation process and several of the older chlorohydrin units have been or now are in the process of being converted from ethylene

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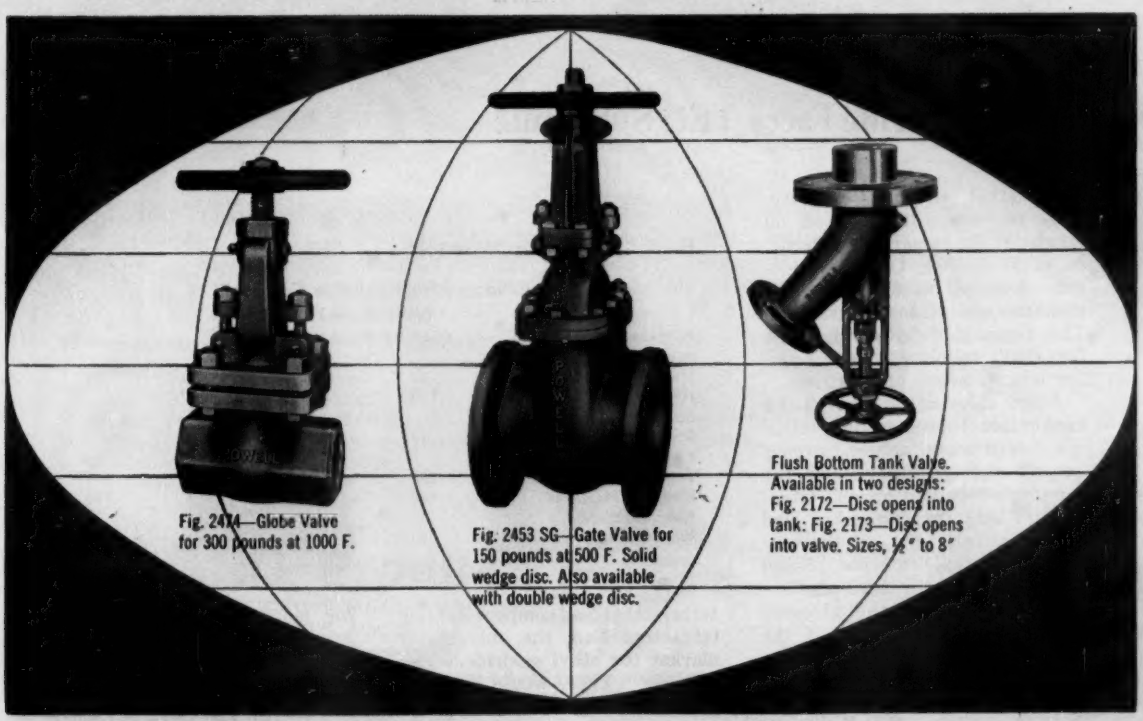

Fig. 2474—Globe Valve for 300 pounds at 1000 F.

Fig. 2453 SG—Gate Valve for 150 pounds at 500 F. Solid wedge disc. Also available with double wedge disc.

Flush Bottom Tank Valve. Available in two designs: Fig. 2172—Disc opens into tank: Fig. 2173—Disc opens into valve. Sizes, ½" to 8"

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oxide over to propylene oxide.

In 1959, ethylene oxide production was about 1,285 million lb. The largest use, accounting for about 890 million lb., was for ethylene glycol manufacture, which in turn was used primarily for vehicular antifreeze. Ethylene glycol based antifreezes now account for 89% of the antifreeze market. Markets per se for ethylene oxide include surfactants and ethanolamines.

The recent promotions by Dow, and particularly Du Pont, of long-lasting antifreezes raise serious doubts as to the size of the future annual glycol antifreeze market. Du Pont's material, believed to be based on ethylene glycol, is claimed to last the life of the car. It will be 1961 before the effects on the ethylene oxide market become known. One new producer, Reading-Chatham Chemical Corp., has announced plans for a new facility, with the output to be sold in large part through the acquired auto specialties organization of Commercial Solvents Corp. Too late to include in capacity table, right, company revealed that it will make 80 million lb./yr. via direct oxidation at Houston.

New Antifreeze May Stunt Ethylene Oxide Market

Estimated Ethylene Oxide Capacity

(Million Pounds)

Producer & Location	Capacity
Chlorohydrin Process[1]	
Dow Chemical	
Midland, Mich.	20
Freeport, Tex.	220
Plaquemine, La.	60
Jefferson Chemical	
Port Neches, Tex.	150
Olin Mathieson	
Brandenburg, Ky.	100[2]
Union Carbide	
S. Charleston, W.Va.	90[2]
Institute, W.Va.	
Total	640
Direct Oxidation Process	
Allied Chemical	
Orange, Tex.	35
Calcasieu Chemical	
Lake Charles, La.	57
General Aniline & Film	
Linden, N.J.	60
Jefferson Chemical	
Port Neches, Tex.	60
Olin Mathieson	
Brandenburg, Ky.	60[3]
Union Carbide	
S. Charleston, W.Va.	33
Institute, W.Va.	77
Texas City & Seadrift, Tex.	391
Torrance, Calif.	55
Whiting, Ind.	77
Ponce, Puerto Rico	110
Wyandotte Chemicals	
Geismar, La.	60
Total	1,075

1. Chlorohydrin capacity applicable with modifications to propylene oxide. 2. Probably being converted to propylene oxide. 3. u. c. = under construction.

Estimated Ethylene Oxide End-Use Breakdown

(Million Pounds)

End Use	1959	End Use	1959
Ethylene glycol	890	Polyglycols	30
Di, triethylene glycol	95	Surfactants	90
Acrylonitrile	50	Misc.	10
Ethanolamines	85		
Glyco ethers	35		1,285

Petrochemicals 3

Ethyl Chloride Faces TEL Substitute

Of ethyl chloride capacity, 90% represents that based on ethylene; the remainder is based on ethyl alcohol. Of ethyl chloride demand, 85% is for the manufacture of tetraethyl lead. The remainder finds small use for ethyl cellulose plastics and for miscellaneous applications.

Ethyl chloride is used in the conventional process for tetraethyl lead manufacture. Recent activities centering around the possible substitution of tetramethyl lead for tetraethyl lead have distinctly clouded the outlook for ethyl chloride. Ethyl Corp.'s tetramethyl lead presumably does not use ethyl chloride in its manufacture, and if the gasoline refiners and marketers, as Standard Oil of California has already announced, go 100% to tetramethyl lead compounds from tetraethyl lead, the only major market for ethyl chloride would collapse. (There would be a corresponding increase in demand for methyl chloride, however.) Ethyl chloride has been an important consumer of ethylene; nongasoline markets for ethyl chloride are insignificant.

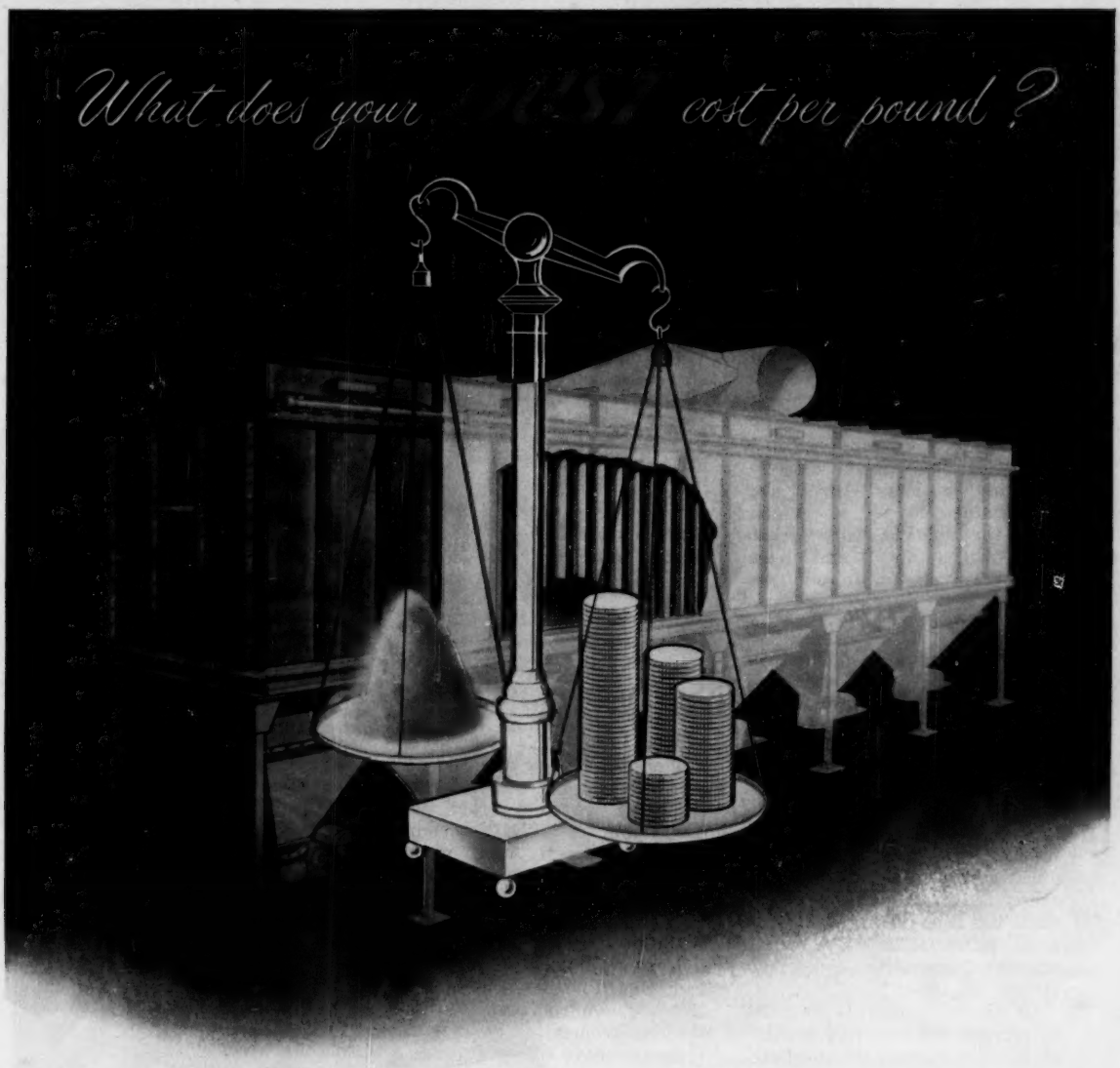
Bulk of Output Now Goes to TEL

Estimated Ethyl Chloride Capacity

(Million Pounds)

Producer & Location	Capacity	Producer & Location	Capacity
Dow Chemicals		U. S. Industrial Chem.	
Midland, Mich.	50	Tuscola, Ill.	50
Freeport, Tex.	150	Shell Chemical	
Du Pont		Houston, Tex.	80
Deepwater, N.J.	60[1]	Others	
Ethyl Corp.		(Brown Co., Montrose of Calif., etc.	10[1]
Baton Rouge, La.	260		
Houston, Tex.	100		770
Hercules Powder			
Hopewell, Va.	10[1]		

1. Capacity based on ethyl alcohol.



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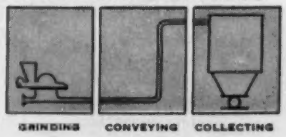

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Petrochemicals 3

Ethyl Alcohol Feels Its Maturity

Synthetic ethyl alcohol production in fiscal 1959 was about 230 million gal. (95% basis) ranking this material third as a chemical ethylene consumer. This derivative is mature and recent growth has been very modest.

The major use for ethyl alcohol is in the production of acetaldehyde and derivatives. Aldol alcohols produced from acetaldehyde face competition from oxo process alcohols made directly from higher olefins. Direct use of acetaldehyde per se, principally for cellulose acetate, has not grown rapidly. Acetaldehyde from ethyl alcohol in addition must compete with that made directly from hydrocarbons by Celanese. As a solvent, ethyl alcohol meets competition from other materials including lower cost isopropyl alcohol.

Biggest Uses: Acetaldehyde and Derivatives

Estimated Synthetic Ethyl Alcohol Capacity
(Million Gallons)

Producer & Location	Capacity	Producer & Location	Capacity
Standard Oil of New Jersey		Texas Eastman	
Baton Rouge, La.	42	Longview, Tex.	14
U.S. Industrial Chem.		Union Carbide	
Tuscola, Ill.	46	S. Charleston, W.Va.	40
Shell Chemical		Institute, W.Va.	10
Houston, Tex.	23	Texas City, Tex.	55
		Whiting, Ind.	15
			245

Petrochemicals 3

Plastics Now Lead Rubber as Styrene Market

Styrene monomer, while more properly a benzene derivative, is also a significant ethylene consumer. Styrene markets in S-type rubber are now second to its use in plastics. When capacity under construction is completed, overcapacity will exist. Monsanto has announced a price drop from 12 to 11.2¢/lb. when its additional capacity comes on stream in 1961.

Of current interest is the route to styrene not involving synthesis of ethyl benzene intermediate. Cosden Petroleum's original 20-million-lb. capacity does not utilize ethylene for ethyl benzene synthesis, recovers ethyl benzene from catalytic reforming streams. Capacity went in several years ago, represented a departure from the established synthesis method. Plans of Koppers to produce styrene in a 70-million-lb./yr. joint operation with Sinclair Oil from recovered ethyl benzene confirms method's attractive economics. Many U. S. refineries have catalytic reforming streams from which ethyl benzene could be recovered and converted to styrene. The largest could make several hundred million pounds each of monomer without resorting to a synthesis step. (The additional 40 million lb. of styrene monomer capacity now under construction by Cosden Petroleum is a variation of the synthesis process; it's said the company hasn't enough ethyl benzene in its reforming stream for additional capacity by that route.) Add to capacity chart, left: 60 million lb. planned for Corpus Christi by Suntide Refining.

Polystyrene markets are strong. Low-cost polystyrene materials are not being displaced by high-pressure polyethylene as some expected. Polystyrene often modified with acrylonitrile, butadiene and other materials can achieve a variety of properties at less cost than most competing thermoplastics. In styrene monomer's second major market: S-type rubber polymer's low cost —below 20¢/lb. when oil extended compared with 35¢ for polyisoprene and 23¢ for butyl rubber—will not put S-type rubber in direct competition with other types for most markets in the near future. Other important markets are styrene-butadiene latexes and polyesters.

Some New Capacity Bypasses Ethylene

Estimated U. S. Styrene Monomer Capacity
(Million Pounds)

Producer & Location	Capacity[3]	Producer & Location	Capacity[3]
Dow Chemical		Union Carbide	
Midland, Mich. / Freeport, Tex.	800 (inc. 200 u.c.)	Institute, W.Va.	110
Monsanto Chemical		Odessa Styrene	
Texas City, Tex.	560 (inc. 200 u.c.)	Odessa, Tex.	40
Koppers		Cosden Petroleum	
Kobuta, Pa.	175	Big Spring, Tex.	60[1] (inc. 40 u.c.)
Shell Chemical		Koppers-Sinclair	
Los Angeles, Calif.	135	Houston, Tex.	70 (pl.)
Foster Grant		Total Capacity	2,100
Baton Rouge, La.	150 (inc. 40 u.c. or pl.)		

1. 20 million pounds from recovered ethyl benzene. 2. All from recovered ethyl benzene. 3. u. c. = under construction, pl. = planned.

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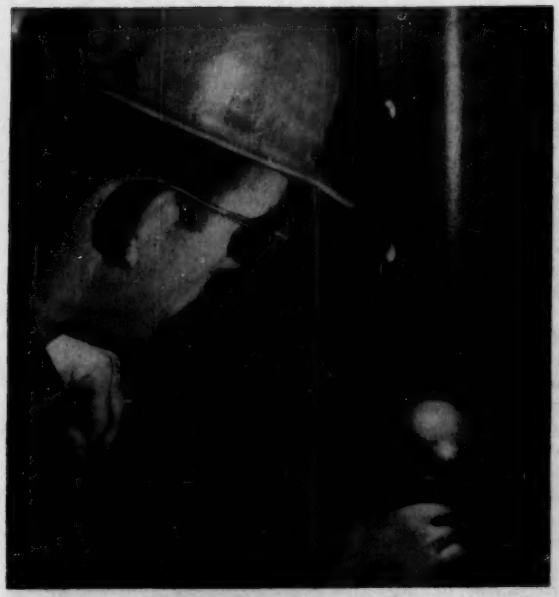

You should see how National Tube tortures USS National PVC Pipe. We heat it in an oven. We stress it with internal water pressure. To check impact resistance, we even drop a 9-pound steel ball on it from ten feet high. The number of test drops vary according to pipe size:

¾″ PVC Pipe—1 drop	2″ PVC Pipe— 7 drops
1″ PVC Pipe—2 drops	2½″ PVC Pipe—10 drops
1¼″ PVC Pipe—3 drops	3″ PVC Pipe—15 drops
1½″ PVC Pipe—4 drops	

These torture tests and drop ball tests are some of the ways National Tube makes sure of the quality of USS National Polyvinyl Chloride pipe. We test it carefully so you won't get any mistakes.

USS National PVC Pipe can handle most acids, alkalies, salt solutions and alcohols. It's available in high-impact or normal-impact. Sizes ½″ to 12″ in diameter. Schedules A, 40, 80 and 120. For further information, write National Tube Division, United States Steel, 525 William Penn Place, Pittsburgh 30, Pa. *USS and National are registered trademarks*

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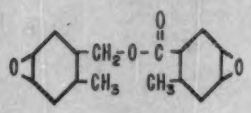
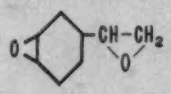
Epoxy Chemical Family Proliferates

Birth rate of new chemicals climbs with the advent of high-purity peracetic acid in epoxidation syntheses.

UNOX 201

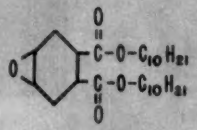


UNOX 206



UNOX 207

FLEXOL 163-D



Word that hundreds of new epoxy compounds with unique properties are now within reach may augur the opening of a bright future for these products. But it is the news behind this news that lends a significant third dimension to this apparent breakthrough in epoxy technology.

In a recent announcement, Union Carbide Chemicals Co. disclosed that it has achieved the first commercial-scale production of essentially pure peracetic acid, prime epoxidizing agent. And in a separate continuous direct process, Carbide uses this peracetic acid to epoxidize cycloaliphatic, aromatic and unsaturated olefinic compounds (*Chem Eng.*, July 25, 1960, p. 68).

▶ **Peracetic Is Key**—The reason why these two interrelated processes ultimately may lead to hundreds of new epoxy compounds lies in the nature of the peracetic acid intermediate, rather than in the direct epoxidation process.

Several companies now compete against users of the established batchwise condensation of epichlorohydrin and bisphenol-A by using the direct epoxidation process, which can produce a greater range of epoxidized compounds. As the epoxidizing agent, these companies use peracetic acid, produced *in situ* by reacting hydrogen peroxide with acetic acid in the presence of formic acid, sulfuric acid or ion-exchange resins as catalysts.

▶ **Purity Broadens Outlook**—Carbide, however, by producing peracetic acid independent of the epoxidation process, exerts control over acid quality that is not possible with the *in situ* operation.

Consisting of a solution of peracetic acid in an inert solvent, the intermediate is anhydrous, since no water is introduced with the feed or produced by the reaction. It doesn't contain strong acid or salts that catalyze side reactions. A small amount of acetic acid, formed as a byproduct, is the only significant impurity.

Being essentially free of impurities, Carbide's peracetic acid remains stable long enough to be transferred from point of origin for use in the separate epoxidation process. And with this degree of purity, it greatly broadens the range of high-quality stable compounds that direct epoxidation can produce.

Carbide's initial offering of commercial quantities of these new epoxide compounds includes both resin-forming materials and plasticizers. Because they incorporate catalysts or hardeners, they are ready-to-use, one-component systems.

▶ **Plastic Epoxides**—Unox Epoxides 201, 206 and 207, have cycloaliphatic structures that eliminate the light-unstable phenolic groups found in conventional epoxies based on epichlorohydrin and bisphenol-A.

Unox 201, easily prepared from low-cost butadiene and crotonaldehyde, provides plastics with low initial color, and resistance to ultraviolet light, heat and air oxidation. It is an excellent light stabilizer for vinyl chloride resins (PVC), where the stabilizing action results from the ability of the epoxide ring to react with hydrogen chloride. This is presumably the action of all epoxy stabilizers including the epoxidized natural oils.

Because of its low viscosity, Unox 201 doesn't require special solvents or diluents, which usually degrade the properties of the

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cured plastic. Better penetration of glass-fiber laminates, prefilled molds, reduction in casting voids and bubble formation are additional advantages resulting from the low viscosity of this product.

Its polymers, containing free hydroxyls, react with drying oils to form air-drying coatings. Combination with fatty acids gives varnishes of remarkable adhesion, alkali resistance, gloss and hardness.

▶ **Handle Like Water**—Unox 206, prepared by Diels-Alder condensation of butadiene followed by direct epoxidation, has a viscosity nearly equal to that of water and is a solvent for many solid anhydride hardeners.

It is highly versatile: the epoxycyclohexane group is reactive under acidic conditions whereas the epoxyethyl part of the molecule is reactive under basic conditions. Hydrogenation yields the cycloaliphatic diol and hydrolysis yields the tetraol. Polymerization provides a three-dimensional resin and when used as a monomer, Unox 206 makes polyglycols with unreacted epoxy groups.

Heat resistance and toughness found in Unox 206 castings are reported as excellent. Textile resins based on 206 impart crease resistance to cotton fabrics.

▶ **Low-Cost Cross-Linking**—Unox 207 forms epoxy plastics said to have excellent high-temperature physical and electrical properties. With its low combining weight, it cuts expenses in cross-linking of low-cost resins and polymers that now are under evaluation in grinding wheels, brake linings, molding, high-temperature encapsulation and tooling.

Under acidic conditions, Unox 207 is hydrolyzed to tetraol. Bromohydrin formation usually occurs on the five-membered ring and hydroxy esters form on the six-membered ring when treated with HBr and organic acids.

▶ **Fungus Resistance** — Incorporation of new Flexol 163-D in vinyl resin permits its use for all sorts of outdoor applications—coatings for house siding, agricultural films and sheeting, electrical insulations—as well as flooring and upholstery.

Flexol 163-D, to be commercially available later this year, combines the compatibility and plasticizing attributes of a primary plasticizer with the stabilizing action of epoxy systems.

▶ **Extra Benefits**—Epoxy plasticizers Flexol EPO and JPO present high oxirane oxygen content and low residual unsaturation that assure maximum compatibility and stabilizing action. Both are reported to impart excellent resistance to extraction by oil and water, also have low volatility.

Often the amount of more expensive metallic stabilizers is reduced by the synergistic stabilizing action of combinations with either Flexol EPO or JPO. These low-cost plasticizers are the result of soybean oil epoxidation.

Another plasticizer, Flexol EP-8, chemically 2-ethylhexyl epoxy tallate, is designed for use in vinyl chloride resins where flexibility as well as heat and light stability are desirable at low temperatures. These properties make Flexol EP-8 an economical replacement for the more expensive azelate, adipate and sebacate plasticizers presently used for low-temperature applications.

Use of all three plasticizers is now extending to other chlorinated polymers and rubbers, chlorinated solvents, nitrocellulose and alkyd coatings.

Many other epoxides are expected to hit the market in the near future, but current commercial production will be limited only to compounds such as those described, which can be synthesized from low-cost starting materials.—**Union Carbide Chemical Co., Div. of Union Carbide Corp., New York, N. Y.** 78A

Plastics

New treatment multiplies plastics' application in lining.

Gamma radiation bombardment of undisclosed polyolefin plastics is turning out compounds of unusual physical properties.

These Mimx 600 compounds have an interesting memory faculty that allows them to resume their original configurations.

Once they have been formed or molded into the desired shape, the plastics undergo Gamma radiation treatment. At that time, they can be heated, reshaped, and locked into any convenient shape. Yet, when proper heat is reapplied, the parts return instantly to their original form within 1% accuracy.

A typical example has been use of Mimx 600 as lining for a complex chamber. To solve the problem of getting the liner through the small opening, engineers used an irradiated tube of Mimx 600, slightly larger than

Newsworthy Chemicals

Page Number is also Reader Service Code Number

Epoxy chemical family lists new members.....78A
Gamma radiation treatment improves plastics.....80A
Insulating fill provides service from −450 to 1,400 F....82A
Phosphating cleaner now available.....82B
Black plastic resin makes stronger piping.....82C
Self-emulsifiable wax forms permanent emulsions.....82D
Polyvinyl butyral resin enters film manufacturing.....82E
Silicone rubber coatings for insulation, cushioning.....82F
Viton-based sealing compound protects gaskets, O-rings..82G

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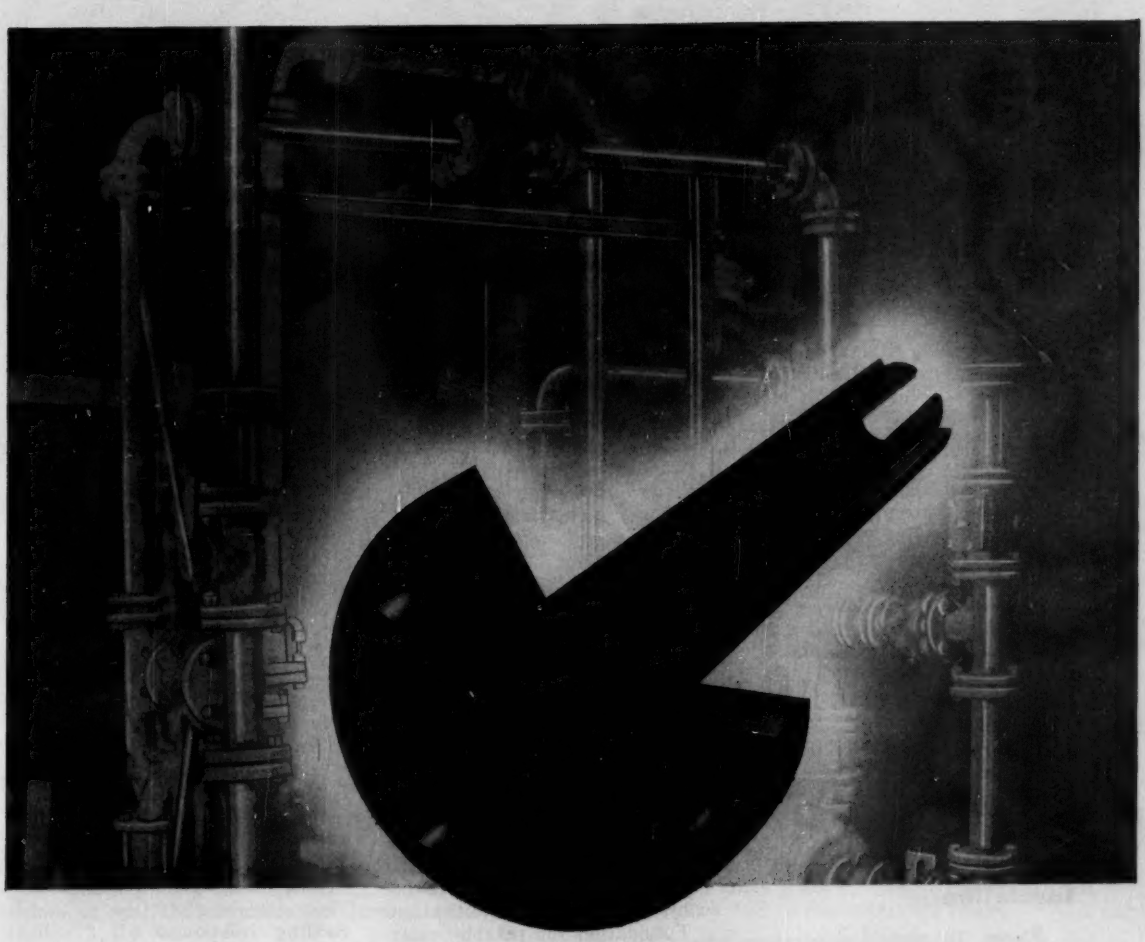

Plant saves $60,000 per month by switch to pipe lined with TEFLON®

In a plant manufacturing a chemical intermediate, excessive maintenance costs and product losses ran as high as $60,000 per month. Such frequent failures occurred in the process involving corrosives at high temperatures and pressures, that onstream time averaged only 75% during the first six months of operation. After a period of testing, more than 1500 feet of pipe lined with Du Pont TEFLON TFE-fluorocarbon resin were installed. Result: No failures of lined pipe occurred in over 2 years of service.

TEFLON TFE resins are unaffected by HCl liquid and vapors, fuming nitric acid—white or red—hydrofluoric acid, organic solvents and reagents. TFE resins are rated for use up to 500°F. Their non-adhesive surfaces prevent plugging by high-viscosity materials. TFE resins do not shatter under vibration, thermal or physical shock.

The liner flared over the flanges provides protection for the steel from the process fluid and eliminates the need for additional gasketing. Installation costs are further reduced because the pipe is equipped with standard flanged fittings which are easily connected. And the need for careful aligning, hanging, welding and other special procedures is eliminated.

In your chemical processes, you can insure long service life and greatly reduced maintenance and downtime by installing pipe lined with TEFLON TFE resins. For more details on properties and performance send for the new bulletin on Lined Pipe . . . and for more general information, ask for the fact-filled booklet, "Designing with TEFLON". Write to: E. I. du Pont de Nemours & Co. (Inc.), Polychemicals Department T-10-8, Room 2526, Nemours Building, Wilmington 98, Del. **In Canada:** Du Pont of Canada Limited, P. O. Box 660, Montreal, Quebec.

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the inside diameter of the chamber. Heat was applied to the tubing and it was locked temporarily into a small spindle by flattening and rolling.

The spindle was then passed through the tiny opening into the chamber and positioned, and the entire assembly heated to approximately 300 F. Upon heating, the "memory" of the plastic caused the tubing to return to its original dimensions, lining effectively the inside walls of the chamber.

Physical characteristics such as resistance to high temperature, acids, solvents and alkalis, do not deteriorate upon repeated heating and cooling.

In addition to incorporating great tensile strength and formability, Mimx 600 compounds are available also in electrically conductive and nonconductive states, and tailored for special applications ranging from solid propellant inhibitors for rocket motors to coverings of igniter parts.—**The Martin R. Klitten Co., Inc., Los Angeles, Calif.** 80A

Insulation

New fill provides service from −450 to 1,400 F.

Perlox, a white, light-weight powder made from an inert silica aggregate containing, in its natural state, myriads of tiny trapped particles of water, is an insulating fill described as completely safe for the majority of cryogenic applications.

During the manufacturing process, trapped water is vaporized at high temperatures, exploding the silica and causing it to expand to many times its original volume. This expansion forms an inorganic cellular structure of countless minute voids sealed by microscopic but sturdy walls.

Once settled in place, Perlox has a density (3 lb./cu. ft.) that affords more insulation per ton of material than other fills in similar applications.

Thermal conductivity at −300 F. is slightly less than 0.10 Btu. (in.)/(sq. ft.) (F.) (hr.). The powder provides very little body to allow moisture pickup, is chemically and physically stable, and is now available in paper bags.—**Johns-Manville Corp., New York, N. Y.** 82A

BRIEFS

Phosphating cleaner that gives smooth, uniform and light (up to 70 mg./sq. ft.) phosphate coatings to ferrous metals, zinc die castings and cadmium plates, is now available. Called Paintite, this product is low foaming, low sludging and free rinsing. It assures paint adhesion and prevents rusting of metals before painting. Minimum temperature control is permissible when used between 140 and 180 F. It can be applied by immersion, spray washer or steam cleaner.—**Turco Products Inc., Wilmington, Cal.** 82B

Black plastic resin, Marlex TR-212, can be extruded to make pipes that sustain three times the accepted standard design stress for ASTM Type III polyethylene pipe. Approved by the National Sanitation Foundation for potable water use, Marlex pipes are light in weight, flexible, easy to install, and inert to acid or alkaline soil. Resin sells for 38¢/lb., and pipes are available in sizes from ½ in. to 2 in.—**Phillips Chemical Co., Bartlesville, Okla.** 82C

Self-emulsifiable wax, with a melting point of 120 F., forms permanent emulsions containing as much as 90 to 95% water in neutral, acid or alkaline solutions. Marketed as Emulsifiable Hywax-122, it is composed essentially of myristyl, cetyl, and stearyl alcohol esters. Wax is odorless, heat stable, and doesn't contain ethylene oxide or added emulsifiers. It is recommended for metal working, cosmetic and textile operations, and as rust inhibitor in oil well drilling.—**Werner G. Smith Inc., Cleveland, Ohio.** 82D

Polyvinyl butyral resin is now available in the form of a highly viscous plasticized dispersion. Resin D-566, when dried at elevated temperatures, produces thermoplastic films that adhere tightly to porous and nonporous surfaces. Films dried at room temperature are easily stripped, nontacky, continuous and water resistant. Applications include baking primers, protective coatings for metal, wood and glass, textile finishing and binder for nonwoven fabrics.—**Shawinigan Resins Corp., Springfield, Mass.** 82E

Silicone rubber coatings with resilience and dielectric strength have been announced: Melcoat S-100 is reported ideal for cushioning fragile or miniaturized components against shrinkage during encapsulation, to minimize arc-over on open leads in electronic units and to impregnate glass-fiber cloth for cables. Melcoat S-200, with its foamlike structure, finds applications wherever thermal insulating coating is required.—**Melpar Inc., Falls Church, Va.** 82F

Sealing compound SR 278-90, an advanced formulation based on Viton, is used for gaskets and O-rings to cope with extreme heat and hard-to-handle fluids. Ideal for most static sealing applications, it keeps its physical and chemical properties from −65 F. to over 600 F., resists solvents, lubricants, hydraulic fluids, acids, bases and hot hydrocarbons. Products incorporating SR 278-90 maintain strength and hardness. **Stillman Rubber Co., Culver City, Calif.** 82G

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Struthers Wells

STANDARD HEAT EXCHANGERS

Standard heat exchangers are suitable for a wide range of services, including heating, cooling, vaporizing and condensing, with the maximum usefulness in the smaller sizes.

Standardization of mechanical design and price offers many important advantages to the user.

Savings may be realized in the user's engineering time, due to ease in procurement, inspection of fabrication, checking drawings and construction details.

In plant layout work, the size of the unit can be quickly established, and the complete information available allows exact details to be fixed at once.

Immediate delivery on most units often results in important savings, due to early completion of the project. Interchangeability allows reuse of the equipment in other services, and increases salvage value.

Important cost savings are available to the user, due to economies in manufacture.

Savings to the process industries, by heat exchanger standardization, are estimated at several million dollars annually.

Struthers Wells has just issued a new bulletin, giving complete mechanical design and prices, covering a number of standard sizes, to about 1200 square feet of surface, and in six principal types.

Thermal design data are included in the bulletin, to allow the user to fix the size of the required unit, in various services.

A large stock of standard exchangers allows immediate shipment, in most sizes. Equipment is available in carbon steel, also with non-ferrous tubes, and in stainless Types 304 and 316.

Complete Guide

to the selection of a standard SW Heat Exchanger is contained in Bulletin B-20. Write for your copy today

STRUTHERS WELLS PRODUCTS

PROCESSING EQUIPMENT DIVISION

Crystallizers . . . Direct Fired Heaters . . . Evaporators . . . Heat Exchangers . . . Mixing and Blending Units . . . Quick Opening Doors . . . Special Carbon and Alloy Processing Vessels . . . Synthesis Converters

BOILER DIVISION

BOILERS for Power and Heat . . . High and Low Pressure . . . Water Tube . . . Fire Tube . . . Package Units

FORGE DIVISION

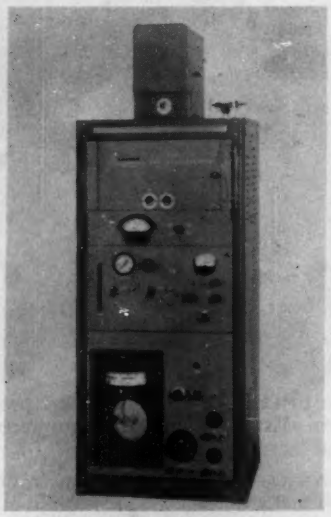
Crankshafts . . . Pressure Vessels . . . Hydraulic Cylinders . . . Shafting . . . Straightening and Back-up Rolls

STRUTHERS WELLS CORPORATION

WARREN, PA.

Chromatographs Get Programmed Controls

New gas analyzers gain in flexibility and accuracy, thanks to built-in automatic programming devices for repetitive operations.



LOENCO Model 17 gas chromatograph is available with either tungsten or iridium detectors.

Column Temperature Increase Reduces Analysis Time

- **Constant gas rate**
- **Programmed temperature**
- **Rated to 900 F.**
- **Pressure compensated**

Now that the gas chromatograph is out of the laboratory and on the firing line for process analysis and control, refinements are coming thick and fast.

One new unit features programmed temperature control that permits operating column at temperatures from ambient to 900 F. Linear or exponential (or any other) temperature programming is obtained with a precut cam that assures exact reproduction of a given temperature program. (Increased column temperature speeds high-boiling fractions through the column, reduces analysis time.)

Model 17 chromatograph strains for accuracy with two symmetrically heated columns —one for analysis, the other for vapor pressure compensation. Organic column packings have significant vapor pressures at higher temperatures.

During operation, vapor pressure of the packing increases at the same rate in each column. Partial-pressure (background) signals at the reference and sample detectors are thus equal and opposite, cancelling out the temperature effect on the packing. Differential flow controllers automatically hold flow rates constant through both columns.—**Loe Engineering Co., Pasadena, Calif.** 84A

OPERATOR checks tape on new MSA programmed chromatograph.

Pencil Marks on Tape Put Machine Through Its Paces

- **Program Tape**
- **Two columns**
- **Temperature stability**
- **Varied data reporting**

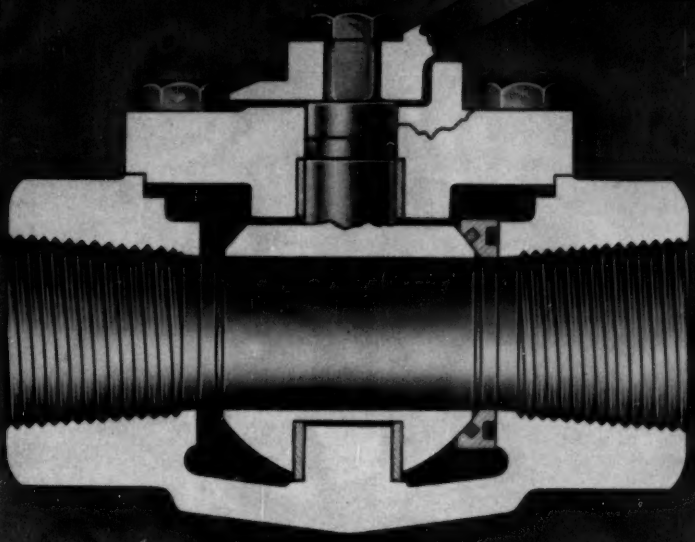
Another new chromatograph uses tape programming for the first time to increase precision and flexibility. Any required combination of time and sequence can be programmed with system, which consists of a motor-driven transparent tape (film) in conjunction with a photoelectric transmitter and receiver.

The tape, a continuous loop of standard 16-mm. film, is graduated in 1-sec. divisions. Programmer simply marks tape with graphite pencil at appropriate intervals (as small as ½ sec.) to achieve desired program sequence. Analysis times from four to 15 minutes are standard, but with motor speed adjustments, shorter or longer time ranges are possible.

Here's what the tape tells the machine to do: select a peak, change sensitivity range, actuate a valve, zero the detector cell, or read out results. Each mark on the tape causes the photo-electric receiver to advance a stepping relay. A wide section of the film (which includes the splice) is blanked out to give a special long pulse which resets the relay system.

▶**Other Features**—New unit

....how can 1 valve replace 3?



Better **FLOW** *than a* **GATE...**

but, unlike gates, the *FLO•BALL* valve doesn't freeze or jam . . . it never leaks . . . the seats don't score . . . it requires no maintenance . . . and just a ¼ turn opens or closes it.

Better **SEALING** *than a* **GLOBE...**

but, unlike globes, *FLO•BALL* gives zero leakage . . . in both directions *without* seat distortion . . . closes easily without massive operators . . . gives more than twice the flow . . . and the fastest action of any valve made.

Better **RELIABILITY** *than a* **PLUG...**

but, unlike plugs, *FLO•BALL* never needs lubrication . . . never freezes, never leaks, requires no maintenance . . . yet it has greater flow capacity than any plug . . . and the *lowest* torque in the industry.

FLO•BALL® does it . . . and does it better!

Hydromatics, Inc.
LIVINGSTON, NEW JERSEY

FLO-BALL

Mail this postage-free card today!

Bearing-fixed ***FLO•BALL*** valves are stocked with flanged or screwed ends, full or reduced port, in standard sizes from ⅛" to 10". They are made to standard ASA dimensions in carbon steel and 316 stainless steel.

Gentlemen:

Perhaps your bearing-fixed ***FLO•BALL*** valves can fill my applications. I require valves

for_____

_____ in these sizes_____.

I now use ball valves in these sizes_____.

PLEASE: ☐ Have salesman call ☐ Send technical data

My name_____ Position_____

Company name_____

Address_____

City_____ State_____

...how the FLO•BALL® reduces your valve costs 3 ways!

1. Reduce initial costs . . . *by using fewer valves per system. FLO•BALL valves are used in place of gates, globes, or plugs.*

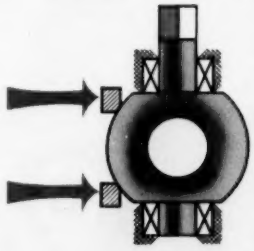
2. Reduce inventory costs . . . *by standardizing on one type valve for all applications requiring gates, globes, or plugs.*

3. Reduce maintenance costs . . . *the FLO•BALL high reliability means less maintenance . . . no lubrication, no freezing, positive sealing. The top loading and replaceable seat reduces overhaul and start-up costs.*

Principles of Operation

In the bearing-fixed FLO•BALL valve all pressure forces exerted on the ball are transmitted to low-friction bearings. The pressure balanced seat results in a sealing force which is designed to insure positive sealing without seat distortion, and to minimize seat-resisting frictional forces. The combination of these low frictional forces accounts for the extremely low operating torque.

FLO•BALL VALVE
Fixes ball • Floats seat



FIRST CLASS PERMIT NO. 40

Mail this postage-free card today!

1357

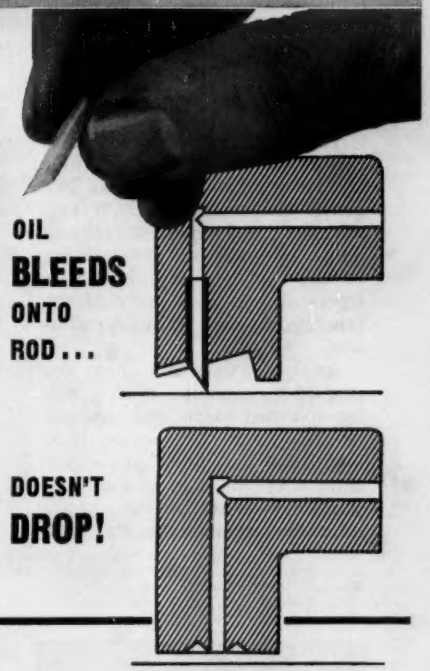
ENGINEERING

NEWS YOU CAN USE ABOUT ENGINE AND COMPRESSOR PERFORMANCE

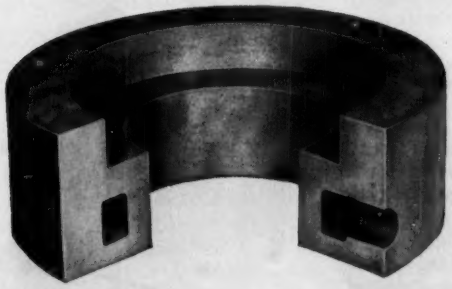
EXCLUSIVE NEW COOK QUILL* ASSURES BETTER LUBRICATION OF HIGH-PRESSURE PACKINGS

Oil "dripping" has caused a lot of trouble in high-pressure packings. The surface tension of the heavier oils tended to foul the nozzle, bleeding the lubricant down inside the cup bore instead of on the rod. Result: intermittent feeding or none at all. A new Cook-engineered drip nozzle design has solved this problem. Key to the new design is a Teflon quill that extends beyond the cup inner bore and actually *touches* the rod. Even after long wear, the quill will be within a few thousandths-of-an-inch of touching the rod. Thus, oil gradually bleeds onto rod . . . doesn't drop. This means that it will maintain a satisfactory oil film on the rod at all times. The exclusive quill is now standard on all Cook steel packings from 4,000 PSI upward. Ask a C. Lee Cook representative to give you the details.

**Patent Pending*



KEEPS PACKING COOL . . . AND IT'S LEAK-PROOF!



Cook's new leak-proof packing cup features circulating water completely *inside of the cup itself* . . . eliminates any possibility of leakage, corrosion or contamination of the material under compression. These are big advantages for all applications—and are naturally of even greater importance on non-lubricated service.

WRITE FOR COOK'S NEW PISTON RING CATALOG

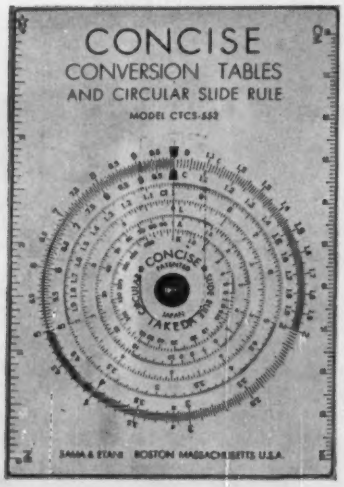
Sixteen-page catalog just off the press. Describes complete line of piston rings manufactured by C. Lee Cook Company, also the special rings of the Airtomics Division. For your free copy, write: C. Lee Cook Company, 958 South 8th Street, Louisville 3, Kentucky.

C. LEE COOK COMPANY
Division of Dover Corporation
Rings and Packings Since 1888

meets the problem of close temperature control with two-zone analyzer arrangement. Outer zone, low temperature, reacts to ambient temperature changes as small as 0.3-deg. F. High-temperature zone, completely surrounded by and insulated from the low-temperature zone, has a working range of 120 to 450 F, controlled within 0.3-deg. F.

The operator can choose different ways to receive results from the machine, such as bar graph presentation, which emphasizes trends in stream components, or spectrum presentation of the complete chromatogram. Operator can also override the tape and operate the unit manually.

Analyzer unit has room for two 50-ft. columns. With a motor-operated valve, the columns can be operated independently or simultaneously in either direction, with columns in series or parallel.—**Mine Safety Appliances Co., Pittsburgh, Pa.** 84B



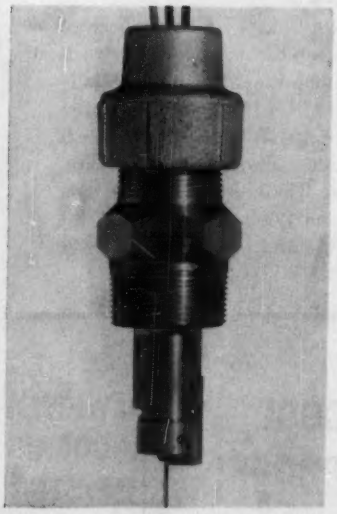
Pocket Slide Rule

Circular rule has better than 7-in. scale.

Most pocket slide rules with the usual six scales are more than matched by this midget. But not only does it perform the usual slipstick duties, it also cleverly provides conversion and other data.

Hidden in the 4 x 3-in. base (less than ⅛ in. thick) is a slide that pulls out to reveal conversion factors for length, volume, flow rate, gas constants, etc. And on its back is a Fahrenheit-Centrigrade conversion chart and a table of the elements.

Size and shape of this versatile little plastic instrument allow it to be conveniently carried (in its protective case) in a shirt or jacket pocket—**Sama & Etani, 26 Medfield St., Boston, Mass.** 88A



Flow Switch

Vane-operated unit magnetically actuates switch.

Watchdog of fluid flow, new V-4 Flotect Switch senses liquid movement in pipes, signals flow or no-flow conditions to operator or automatic equipment. Vane on switch extends into line, is moved by fluid movement to actuate switch, does not respond to pressure variations in fluid.

Switch housing is one-piece in stainless steel or brass. Electrical assembly can be removed from housing for adjustment or inspection without shutting down liquid flow. Working pressure is 2,000 psi.

Switch, according to manufacturer, is the only explosion-proof, high-pressure, magnetically-actuated flow switch that costs less than $100.—**W. E. Anderson, Inc., Kansas City 14, Mo.** 88B

Spray-on Insulation

Inaccessible areas easily covered with spray gun.

Technique of mixing fast-setting components after they leave the gun is basis for new spray system for applying rigid urethane foam. Layer built up has high thermal and corrosion resistance.

Sprayed components reach the surface as a liquid, instantly expand and set tack-free within five minutes. A 7-in. layer can be applied to vertical surface without sag or drip. Flow rate of 3-5 lb./min. covers with a volume equivalent to 10-20 board ft./min. Rigid coating has a density of 2.5-3.5 lb./cu. ft. Finished surface may be painted.

Approximate cost of unit which includes heater, transformer, two 10-gal. pressure feed tanks, cleaning tank, spray gun, and hoses: $2,600.—**DeVilbiss Co., Toledo, Ohio.** 88C

Gear Reducer

New line has radiation and convection cooling.

Fan-cooled gear reducers give right-angle power transmission up to 66 hp. New cooling system features maximum diameter fan to force cooling air along built-in channels formed

Progress Report... —CELLOSIZE hydroxyethyl cellulose

Water-soluble gum takes up where nature leaves off

One of the most adaptable of the synthetic water-soluble gums is CELLOSIZE hydroxyethyl cellulose. This white, fluffy-to-granular powder is non-ionic and readily soluble in hot or cold water. The various grades have many applications in a wide variety of industries.

Paint-Making Timesaver...

In latex paints, CELLOSIZE WP-4400 has high thickening power at low concentrations. It is also soluble and non-gelling in water at temperatures up to boiling. You can add WP-4400 to pigment grinds and still obtain instant color development during hot let-down with phthalo colors. The ease of solution and low-foaming characteristics of WP-4400 speed preparation of latex paints.

Latexes thickened with WP-4400 exhibit good shelf life, stability to pH variations, and freeze-thaw resistance. Clean, bright colors are assured, with little tendency to form pinholes in the film. Other desirable properties are viscosity stability, excellent flow-out, and good scrub resistance.

More Paper Strength...

Preliminary tests show that paper products such as towels and tissues gain in wet strength, absorbency and softness when treated with CELLOSIZE HEC and glyoxal. This also suggests evaluation with non-woven fabrics. Coatings made from HEC are impervious to both liquid and vapor forms of oils, greases, and most solvents. Fiber containers lined with a film made from CELLOSIZE HEC have held lubricating oil, ethylene dichloride, and other hydrophobic solvents without leakage for two years.

Paper sized with CELLOSIZE HEC has excellent gloss and hold-out for oil-based inks, varnishes, and lacquers. Only about 0.1 to 0.5 pounds of the gum per 1000 sq. ft. of paper is usually required for this purpose. Cooling the paper to prevent gelation is not needed.

CELLOSIZE HEC used as a textile finishing size contributes stiffness with less solids, better heat stability, and easier preparation than the usual starches. Soil removal from ironed fabrics is also greatly facilitated.

Hydroxyethyl cellulose is being used in textile emulsions where solution stability and good dilution stability are desired.

Smoother Cosmetics...

As a binder, thickener, stabilizer, and film-former in cosmetic preparations, CELLOSIZE HEC is unexcelled. Its ease of solution and efficient thickening ability are time-savers in formulating shampoos, creams, and lotions. Tolerance for concentrated aluminum salts makes HEC ideal for deodorant creams, lotions, and sticks. The chemist may compound with either anionic or cationic additives without coagulating the system. Lubricity and pleasant "mouth feel" are imparted by CELLOSIZE HEC to many pharmaceutical preparations.

Ceramic Color-Dispersant...

In dry-molding ceramics, this CARBIDE non-ionic gum is a useful binder and water-retaining agent. It produces powders that contain enough moisture to be plastic under pressure.

Luminescent pigments, such as used for coating instrument dials, and other ceramic colors are effectively dispersed with CELLOSIZE HEC. The non-ionic serves as both dispersant and binder for the pigment-glass flock material sprayed on colored glassware and later fired.

There are many more applications for CELLOSIZE HEC. Its high thickening efficiency and compatibility with borates facilitate the formulation of adhesives. Coating rubber or plastic goods with a solution containing CELLOSIZE HEC prevents sticking and protects them from marring during processing. Agricultural sprays, dusts, and wettable powders can be efficiently prepared with CELLOSIZE HEC. Its colloidal action is of value in electroplating solutions, giving a brighter finish to metal, particularly in cadmium plating.

More Information Available...

Further information on CELLOSIZE HEC—properties, where and how to use it, plus other valuable data—can be obtained from a Technical Representative in any CARBIDE office. For a technical bulletin listing many suggested applications, please mail the coupon.

Tear out this coupon. Check the boxes on which you'd like more information, and mail to Dept. H, Union Carbide Chemicals Company, Division of Union Carbide Corporation, 270 Park Avenue, New York 17, N. Y.

- ☐ CELLOSIZE HEC
- ☐ 1960 Physical Properties of Synthetic Organic Chemicals—a comprehensive description of the properties and applications of nearly 400 CARBIDE chemicals.

Name_____

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And remember, you can obtain the services of a CARBIDE Technical Representative who's backed by Technical Specialists.

CELLOSIZE and UNION CARBIDE are registered trade marks of Union Carbide Corporation.

UNION CARBIDE CHEMICALS COMPANY

UNION CARBIDE

by external ribbing. Cooling efficiency is independent of mounting position.

Gear and bearing lubrication is automatic and positive in either direction of rotation in both fixed- and adaptable-base models. Adaptable unit has special shaft seal which keeps oil out of shaft bearings when unit is in vertically downward position. — **Foote Bros. Gear and Machine Corp., Chicago, Ill.** 88D

Flaring Tool

Flare copper, aluminum and brass with new unit.

A new flaring tool, said to give perfect flares every time, produces 45- or 37-deg. flares. "Ridgid" tool has all working parts locked together to save exasperating loss of one part.

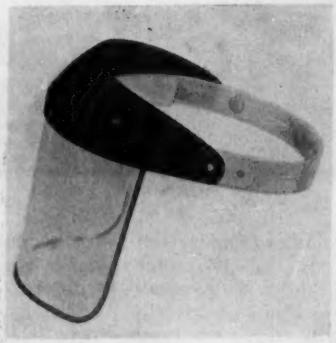
Hinge and aligning pins lock yoke, die bars and tubing into exact alignment, and bottom of yoke automatically gages flares for uniform length. Flare wall thickness is controlled by an automatic feed release that prevents thinned walls. Operation yields burnished flare.—**Ridge Tool Co., Elyria, Ohio.** 90A

For More Information

about any item in this department, circle its code number on the

Reader Service

postcard (p 195)

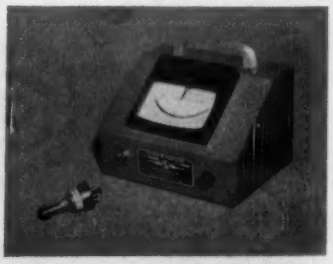


Face Shield

Inexpensive unit weighs less than 4 oz.

Designated Feather-Lite F-90, a new face shield weighs only 3¼ oz. complete with head band and 6 × 11½-in. window. Polyethylene head band adjusts in ¼th sizes from 6⅝ to 8, will not mildew or rot and may be cleaned with soap or detergent.

Window-deflector section pivots easily on friction joints which hold the shield in any working position. All parts may be replaced separately in the F-90, which costs less than $2 in quantity.—**Fibre-Metal Products Co., Chester, Pa.** 90B



Vacuum Controller

Control range is 0.2 micron through 200 mm. Hg.

Control sensitivity within 1% of the setting on direct reading scale is claimed for new vacuum controller. Sensing element is a thermopile. Matched, interchangeable gage tubes are available that are independent of atmospheric pressure changes.

New line comes in four models, which have ranges of 0-100 micron Hg, 0-1,000 micron Hg, 0-20 mm. Hg, and 10-200 mm Hg. Instrument uses 90-135 v., 60-cycle a.c. power.—**Hastings-Raydist, Inc., Hampton, Va.** 90C

Rupture Disk

Bolted, union, and screw-type designs are available.

A new rupture disk, designed to withstand operating pressures closer to rupture pressure than do previous designs, is now available in the prebulged style. Called H-O and H-O-V, disks are for vacuum or pressure service.

New CPV disk by same manufacturer, fragile but strong, is particularly suited for vacuum installations. These disks round out line which includes ¼-through 30-in. disks for pressures from 5 to 50,000 psi. Units available in carbon or alloy steels.—**Fike Metal Products, Blue Springs, Mo.** 90D

Solvent Extractor

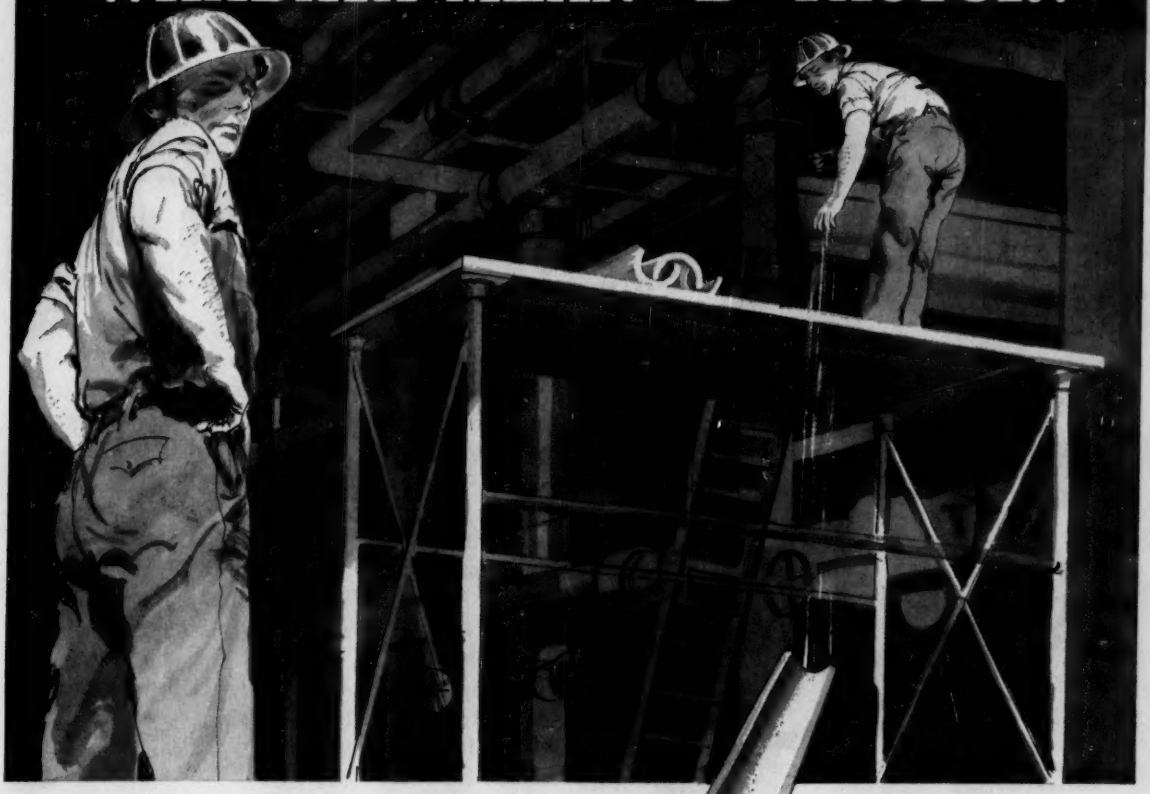
Two-column contactor for research and development.

A new two-column solvent extractor, originally developed for atomic metals purification, is now available for research and development work in organic and inorganic chemical processing.

Unit consists of an extraction-scrub column of the pulsed sieve-plate type with precision

EQUIPMENT NEWS
Continues on . . . Page 181

WHADAYA MEAN "B" FACTOR?



Use Unibestos, the rugged insulation

"B" is for Breakage . . . one of the most important cost factors on any insulation job. When you load for shipment, unload for warehouse, reload for job site, then unload and spot for installation, it takes a *rugged* insulation to get there with *no breakage.* And that's just what Unibestos will do for you. And how "B" factor saves cleanup time, too. No wonder 15% to 20% savings is not unusual.

That's also one of the reasons why Unibestos is worth more. Yet it continues to sell at competitive prices.

Hit it, drop it, ship it in ordinary cardboard cartons without packing and you still come up with tough, efficient insulation sections. Unibestos eliminates breakage and shrinkage; defies thermal shock, fumes, acids and moisture; cuts application time and costs; and guarantees real insulating efficiency.

Available in a full range of standard pipe sizes and in block form. Single thicknesses up to five inches. Specials to 44" O.D. in half sections.

Write today, on your letterhead, for Bulletin No. 65610.

Tumbling apparatus illustrated above was used to simulate jars incurred in LCL shipments. After 29.2 minutes (204 revolutions) Magnesia insulation is completely broken down. Unibestos remains O.K. for installation because of its exclusive long-fibered *Amosite* asbestos.

UNIBESTOS

worth more, yet sold at competitive prices

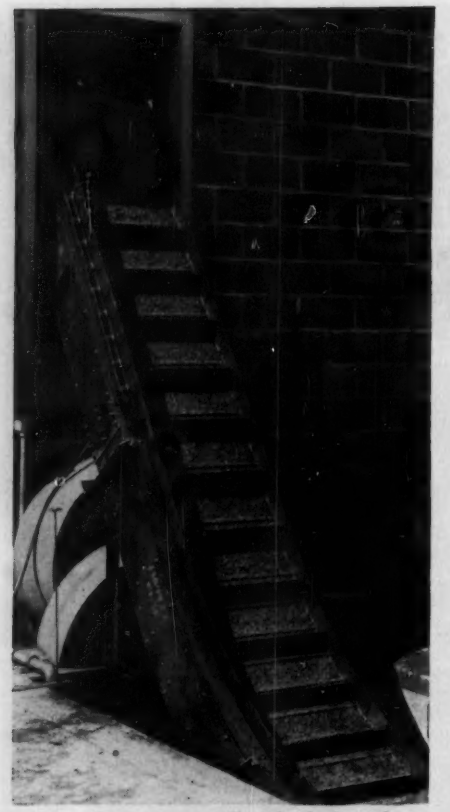
UNARCO®

UNARCO PRODUCTS

• UNIBESTOS, Amosite Asbestos Pipe Covering and Block • Calcium Silicate Pipe Covering and Block • 85% Magnesia Pipe Covering and Block • Mineral Fiber Block • Wrap-On Insulation • Lace-On Insulation • Turbine Blankets • Insulating and Finishing Cements • Asbestos Textiles • Packing and Gasketing.

UNION ASBESTOS AND RUBBER COMPANY • FIBROUS PRODUCTS DIVISION

DEPT. 257, Bloomington, Illinois



Apron Conveyors—excellent for horizontal or inclined conveying.

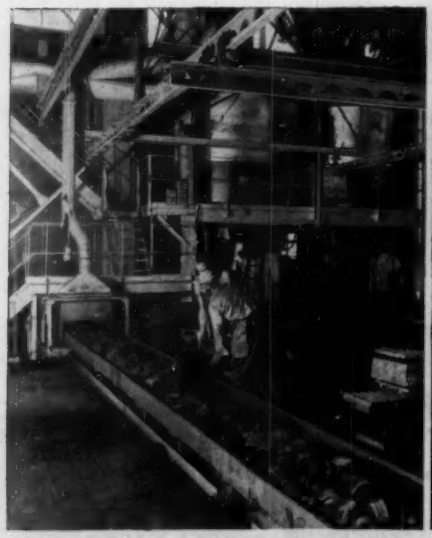
JEFFREY CONVEYORS TO MEET YOUR MATERIALS HANDLING NEEDS

COMPONENTS, ACCESSORIES FROM STOCK

The plant engineer must treat every conveying job as a brand new project; the material to be moved has its own peculiar characteristics; distances, elevations and surroundings vary to affect operating conditions. Selecting a conveyor requires a thorough knowledge of the factors involved.

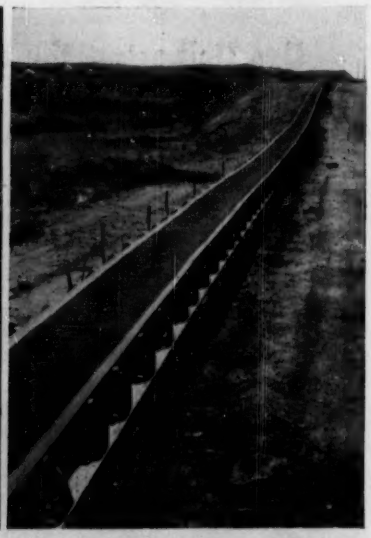
That's where Jeffrey's 75 years of materials-handling experience steps in to help. Based on this know-how, our engineers recommend the type of conveyor that will move the material most efficiently. They help plan it for maximum performance at most economical first cost; will even supervise installations.

Jeffrey conveying equipment maintains high production, lightens labor's burden and reduces operating costs. Send for data. The Jeffrey Manufacturing Company, 909 North Fourth Street, Columbus 16, Ohio.



Vibrating Conveyors—transport hard-to-handle materials easily.

Spiral Conveyors and Bucket Elevators—team up for horizontal and vertical travel.



Belt Conveyors—move materials swiftly across country or on short hauls.

Bin Valves • Car Pullers
• Chains • Idlers • Pulleys
• Sprockets • Take-ups
• Buckets • Pillow Blocks

JEFFREY

CONVEYING • PROCESSING • MINING EQUIPMENT...
TRANSMISSION MACHINERY...CONTRACT MANUFACTURING

Versatile low-cost

FEDERATED ZINC DUST

Now being used as a reducing agent, precipitating agent, purifier, catalyst, polymerizing agent, and in rust-resistant paints, bleaches, pyrotechnics, soot-removal, pipe thread compounds, and Sherardizing, zinc dust often does a better job than other compounds at less cost. Federated Zinc Dust is 97% metallic zinc, with a 97% through 325 mesh screen fineness. Send for half-pint experimental lot, and call on Federated's research and engineering assistance. Write or call: Federated Metals Division, American Smelting and Refining Company, 120 Broadway, New York 5, N. Y. or your nearby Federated sales office.

ASARCO

AMERICAN SMELTING AND REFINING COMPANY

FEDERATED METALS DIVISION

Where to call for information:

ALTON, ILLINOIS
Alton: Howard 5-2511
St. Louis: Jackson 4-4040

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Orleans 5-2400

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Fairfax 2-1802

BOSTON 16, MASS.
Liberty 2-0797

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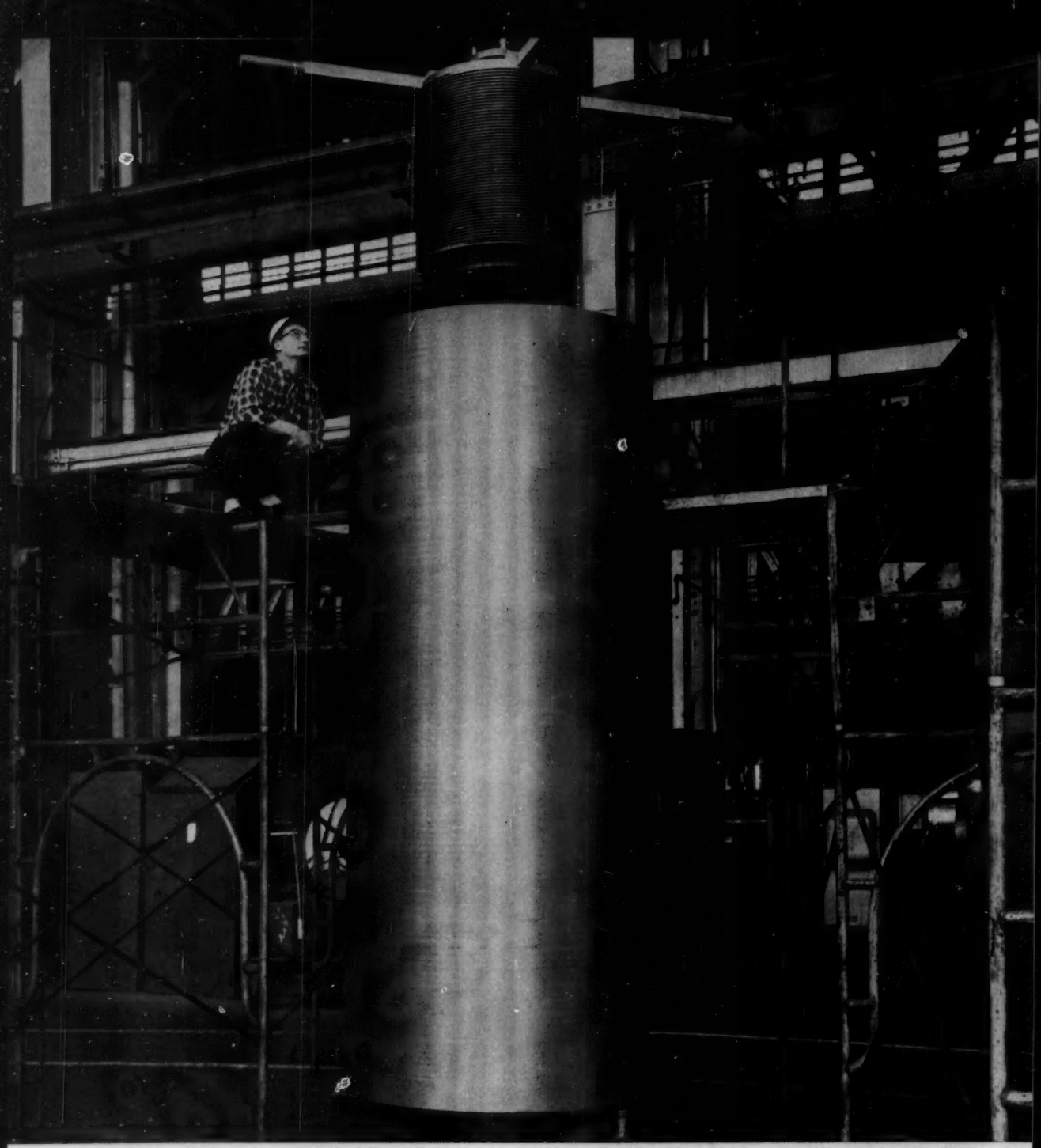

Hydrostatically tested in excess of 70,000 psi. This Bethlehem forged pressure vessel is of two-layer, shrink-fit construction. The two shells and all the head closure parts were forged from alloy steel. The vessel measures 122 inches in length and weighs a little over 30 tons. Diameter inside is 18 inches; outside it's 49½ inches.

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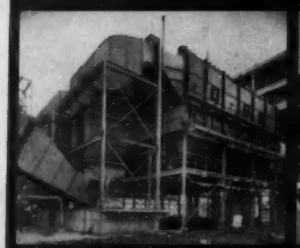

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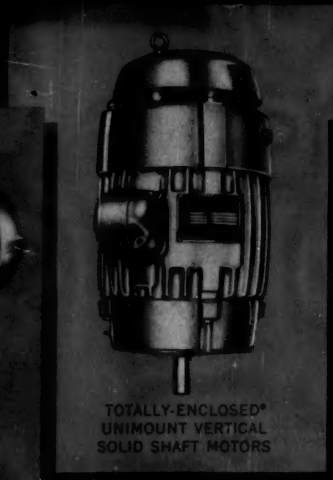

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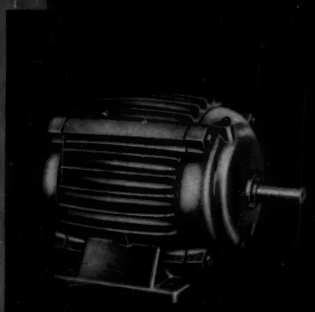

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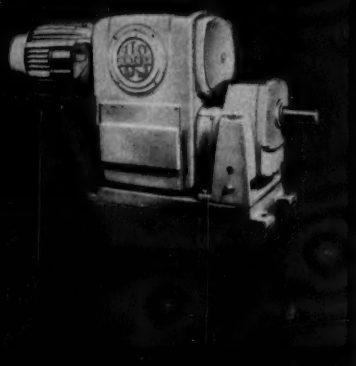

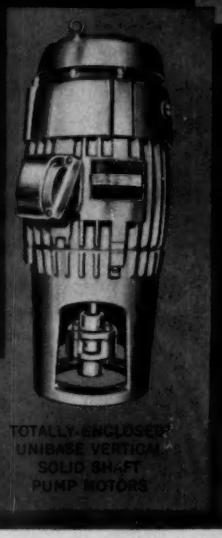

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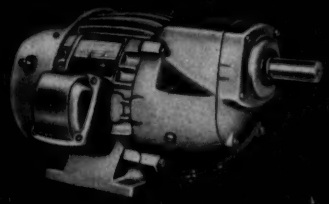

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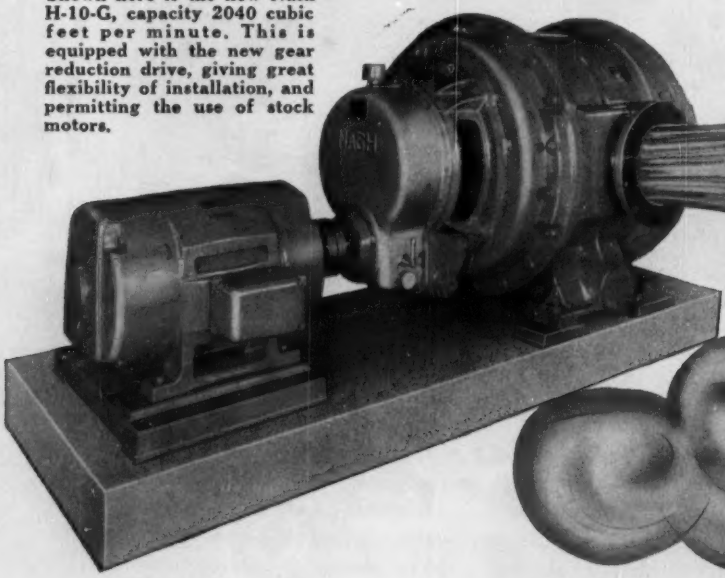
P. O. Box 2058, Los Angeles, California or Milford, Connecticut

Nash Compressors Tame "Hard-to-handle" Corrosive Gases

The reasons for the success of Nash Compressors in handling "dirty" and corrosive gases are simple. First, Nash Compressors have no internal parts in wearing contact, or requiring close tolerances and internal lubrication. Second, because of the Nash operating principle, a variety of liquids can be employed as the compressant medium, protecting the interior from corrosive action. Third, the pump casing may be fabricated from a variety of special metals and alloys. That is why Nash Compressors take these rugged jobs in stride.

Nash Vacuum Pumps offer the same basic advantages when handling corrosive gases, and reliably maintain vacuums up to 29.50 inches of mercury.

Shown here is the new Nash H-10-G, capacity 2040 cubic feet per minute. This is equipped with the new gear reduction drive, giving great flexibility of installation, and permitting the use of stock motors.



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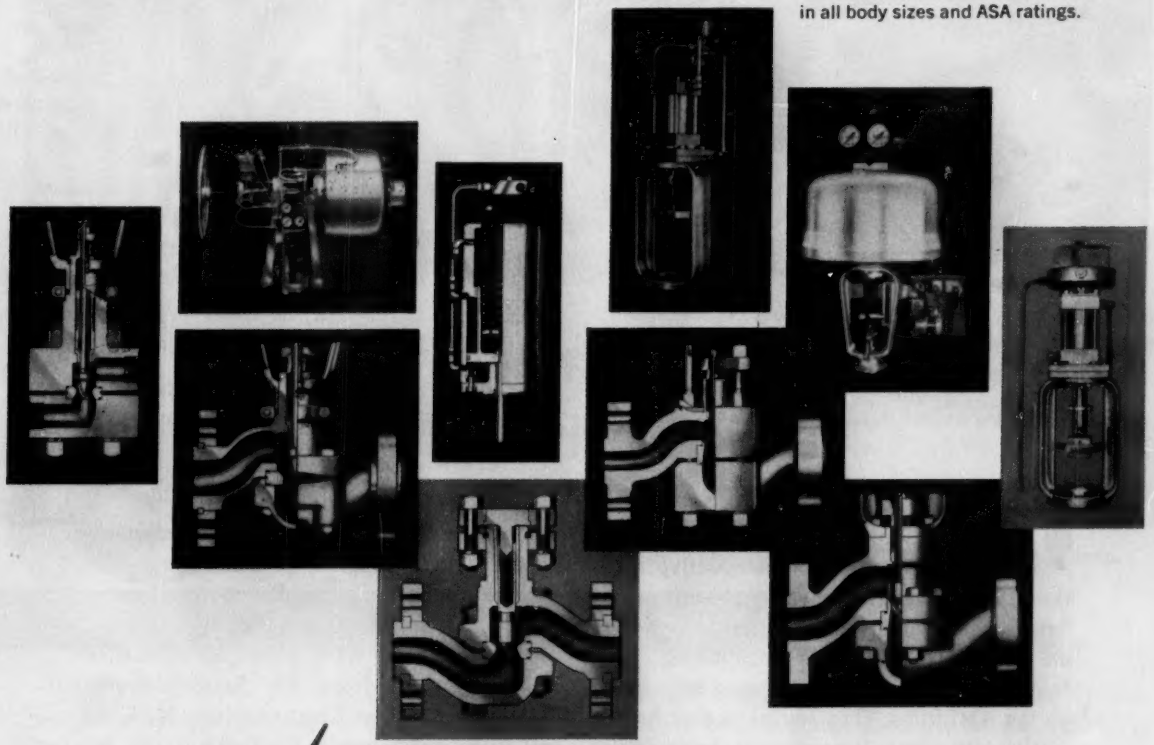

Annin **VALVES**

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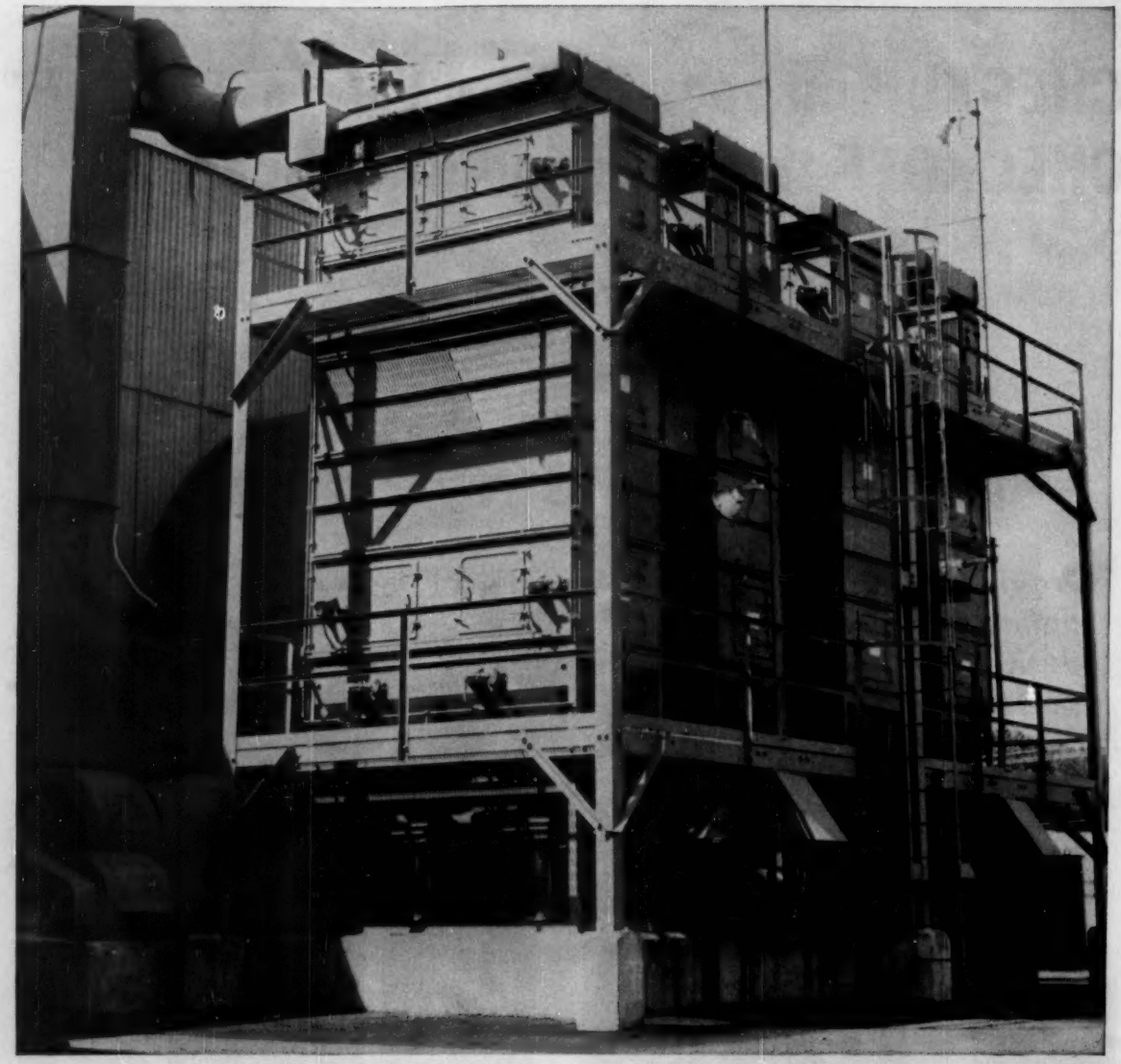

Death trap for radioactive dust

■ This battery of AAF AMERjet dust collectors is snuffing out the radioactive dust threat at an Eastern nuclear engineering and development plant. All hooded operations on radioactive materials—machining, cutting, forming, shaping—are being exhausted by the AMERjets. They settle the dust harmlessly into their hoppers, discharge only *clean* air to the atmosphere.

The AAF AMERjet is a highly efficient reverse jet fabric collector. It will handle heavy dust loadings of materials of varying nature with a constant pressure drop that assures accurate control. For more information, call your local American Air Filter representative or write direct for AMERjet Bulletin 279. Address: Mr. Robert Moore, American Air Filter Company, Inc., 326 Central Avenue, Louisville, Kentucky.

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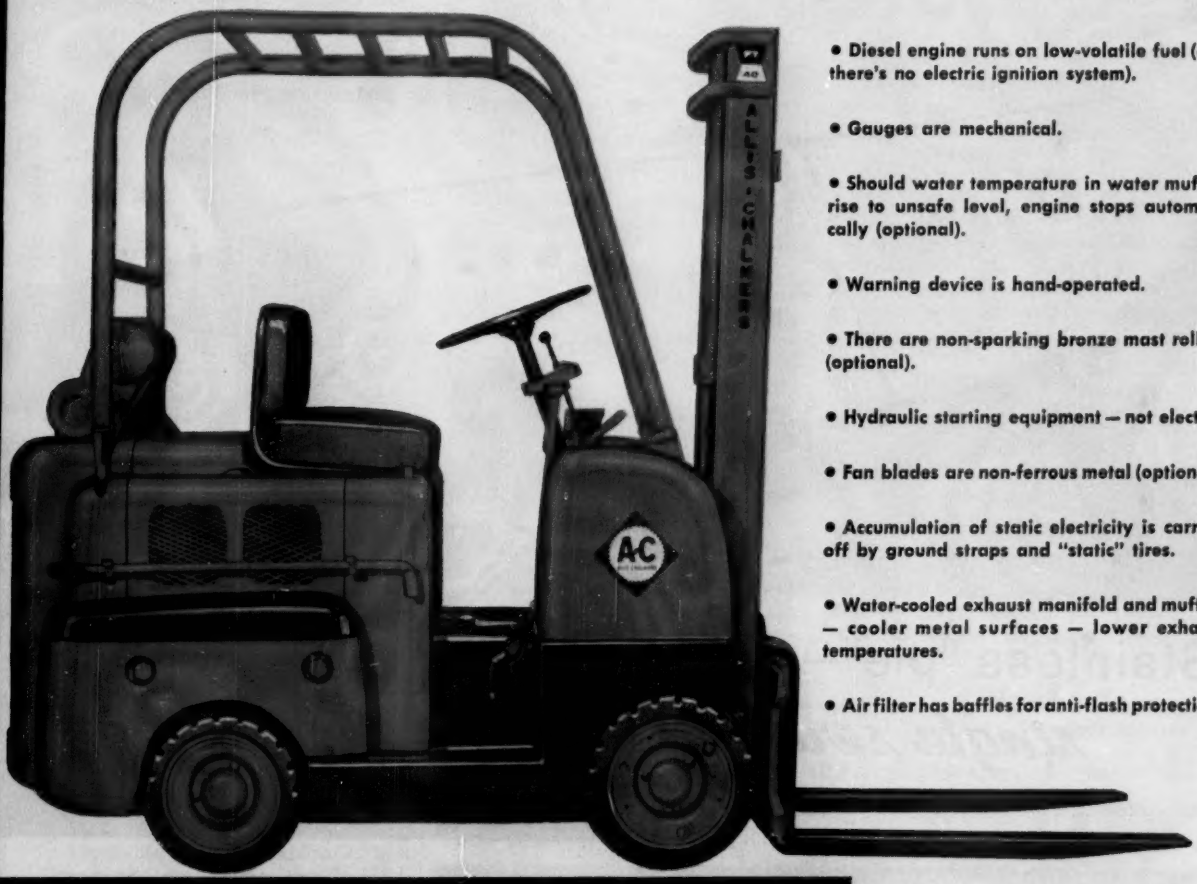
Allis-Chalmers DX safety diesel lift trucks go BEYOND Underwriter's Laboratories DS standards in safety — they were developed to provide exceptional protection where there is possibility of explosion — where a single spark could touch off a disastrous fire. Approved by Mill Mutual Fire Prevention Bureau, they are used effectively in a number of plants where explosive conditions exist.



- **Diesel engine runs on low-volatile fuel (and there's no electric ignition system).**
- **Gauges are mechanical.**
- **Should water temperature in water muffler rise to unsafe level, engine stops automatically (optional).**
- **Warning device is hand-operated.**
- **There are non-sparking bronze mast rollers (optional).**
- **Hydraulic starting equipment — not electric.**
- **Fan blades are non-ferrous metal (optional).**
- **Accumulation of static electricity is carried off by ground straps and "static" tires.**
- **Water-cooled exhaust manifold and muffler — cooler metal surfaces — lower exhaust temperatures.**
- **Air filter has baffles for anti-flash protection.**

Whether you need fire safety or unmatched material handling efficiency, you'll find an Allis-Chalmers lift truck your wisest choice. See your dealer for complete information. Send for Bulletin BU-638 on DX safety diesel lift trucks — 3000- to 8000-lb cap. Allis-Chalmers, Milwaukee 1, Wis.

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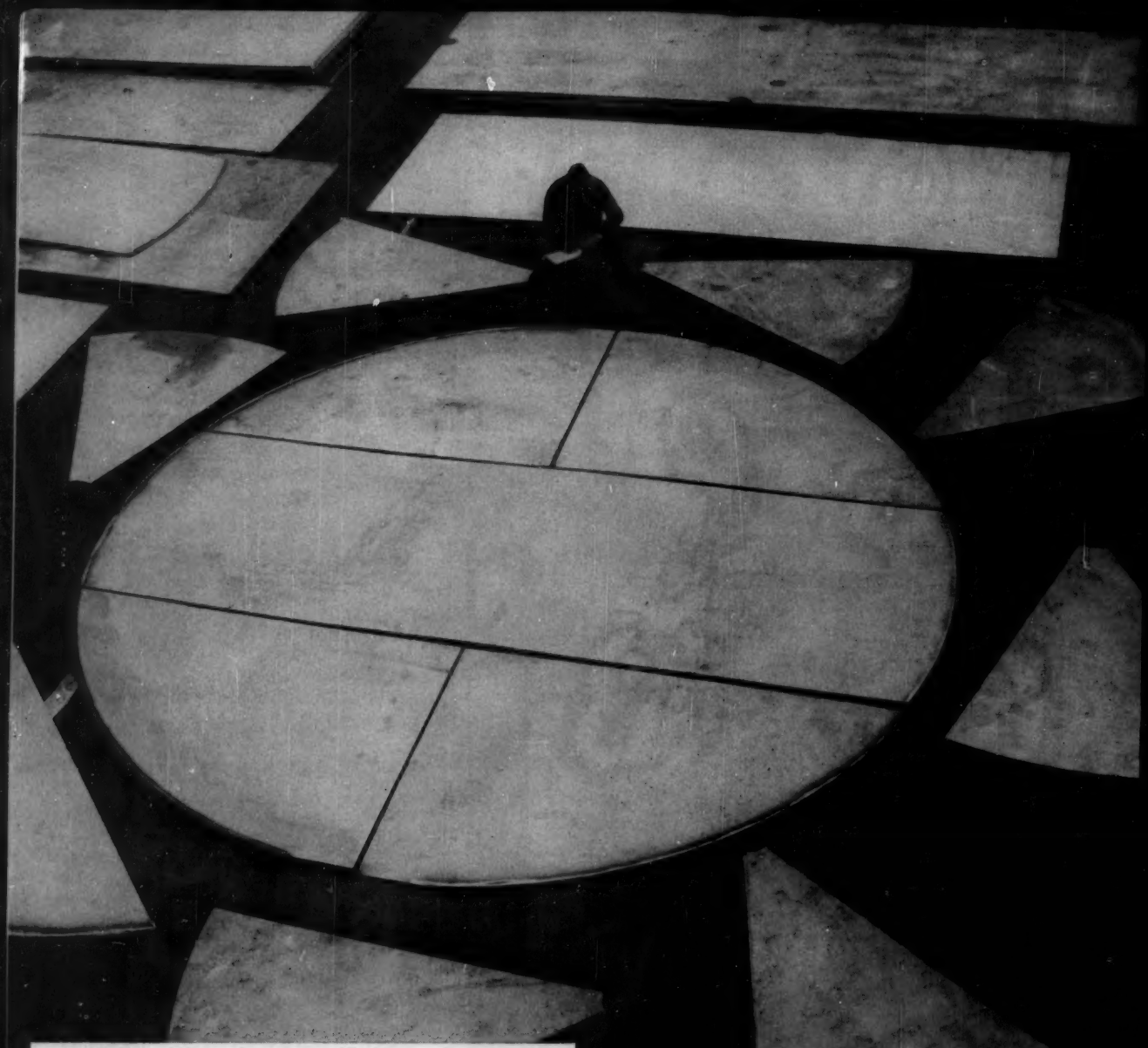

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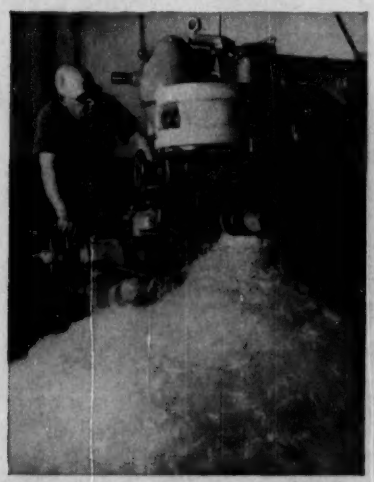
U.S.I. CHEMICAL NEWS

August ★ A Series for Chemists and Executives of the Solvents and Chemical Consuming Industries ★ 1960

Polyethylene Used for Insulators in Nuclear Weapons Research Work

Two large polyethylene insulators, 18½ inches in diameter, have been made for use with a unique electrical switch in the discharge of heavy current loads from large condenser banks. Insulators and switch are reported to be part of research equipment used by nuclear physicists in the simulation and study of various aspects of nuclear weapons systems.

Polyethylene was chosen for its good insulating qualities, it is reported. Each insulator is said to be capable of withstanding voltages in the neighborhood of 100 kilovolts. The insulators were carefully milled to insure design compatibility with the special two-million-ampere switch.



Milling polyethylene insulator for use with unique electrical switch in nuclear weapons research. (Photo courtesy Boeing Airplane Co.)

New Chlorine Booklet Is Offered by U.S.I.

Facts about chlorine are detailed in a concise new booklet just released by U.S.I. Illustrated with photographs, drawings, graphs and charts, the 28-page booklet describes chlorine's chemical and physical properties in detail, and gives information on shipping, handling, safety measures and applications.

The company is preparing a similar publication on caustic soda which will be available shortly. For your copy of the chlorine booklet, write to the Technical Literature Dept., U.S.I. Chemical News, 99 Park Avenue, New York 16, N. Y.

Sodium Process Developed by U.S.I. Proves Economical for Desulfurizing Coke Oven BTX

Thiophene Levels in Benzene-Toluene-Xylene from Coke Oven Sources Reduced to Less Than 1 PPM. Purities Match Those Of Petroleum Products, with Treating Costs of Only 1-2¢/Gal.

Recent demands for low-thiophene benzene and toluene are creating new interest in desulfurization processes. To remain competitive with low-thiophene petroleum fractions, coke oven producers today must further treat their light oils to reduce thiophene content. Usual specifications are less than 1 ppm. Workable treating processes developed so far have proved economical only for very large scale coke oven operators who can invest in extensive equipment. The smaller operator has remained handicapped, and has been seeking methods involving lower capital outlay.

Recently, U.S.I. has been working with coke oven producers on the application of sodium desulfurization to this problem, with some very practical results. It has been found that, for only a little over a cent per gallon in treating costs, light oil feeds from coke oven sources can be purified to the desired levels. Further, this processing method is economical even for the small-scale producer.

Two U.S.I. Processes Available

Two general processes have been worked out by U.S.I. for the sodium desulfurization of light oil feeds in the vapor phase. In one, a mechanically agitated high-surface-sodium bed is used. In the other, vapor fluidized high-surface-sodium is employed.

Many samples of light oil from various parts of the country have been investigated in pilot units of these two types at U.S.I.'s research laboratories. The results of three such investigations, with calculated direct operating costs, are given in the

MORE

PILOT PLANT DATA—SODIUM DESULFURIZATION TEST RUNS

Acid-Washed BTX Sample	Process	Temp.	Na Level #/gal. feed	Contact time, sec.	Orig. thiophene content ppm	Final thiophene content ppm	Cost of treatment ¢/gal.*
A	Mechanically Agitated Reactor	450–500°F	.025#/gal.	10 sec.	45 ppm	less than 1 ppm	1.4¢/gal.
B	Fluidized Bed Reactor	450–500°F	.013#/gal.	10 sec.	1,000 ppm	less than 1 ppm	1.1¢/gal.
C	Agitated Reactor	450–500°F	.01#/gal.	10 sec.	170 ppm	less than 1 ppm	1.7¢/gal.

* These are total calculated operating costs—including raw materials, utilities, labor and maintenance—for 3 different locations and different capacities. Cost figures are therefore not comparable.

National Distillers—Food Machinery Joint Venture Gets Rocket Fuel Contract

Contracts for multi-million pound quantities of unsymmetrical dimethylhydrazine have been awarded by the Air Force Air Material Command to a joint venture of the Food Machinery and Chemical Corp. and the U.S.I. division of National Distillers. These contracts total more than $20,000,000. The material, called DIMAZINE* by the joint venture, is a storable, high-energy liquid rocket fuel.

FMC and U.S.I. pioneered in the commercial development of unsymmetrical dimethylhydrazine, and have been its principal producers for several years. The Air Force's DIMAZINE requirements will be produced in expanded facilities at Baltimore, Md.

DIMAZINE is a completely synthetic fuel. It is used with liquid oxidants in bipropellant engines of the type that power most of this country's large rocket vehicles as well as various smaller ones. Unsymmetrical dimethylhydrazine is unique in being the only synthetic fuel used in a substantial number and variety of the nation's operational rocket programs for scientific and military purposes.

*Registered Trademark of Food Machinery and Chemical Corp.

CONTINUED

Sodium Desulfurization

accompanying table. These figures are for BTX mixtures. The same processes can be used to treat benzene-toluene, benzene alone, or toluene alone—at still lower operating costs.

Distillation Removes Many Impurities

While the whole crude light oil may be desulfurized with sodium, distillation prior to sodium treatment is a more economical method for removing many of the sulfur compounds and other impurities present. Thiophene, of course, cannot be removed economically by distillation. An acid wash prior to sodium treatment is also used frequently to lower the level of some impurities.

Since purity requirements are usually less critical for xylene than for benzene and toluene, it is generally considered preferable to separate xylene from BTX mixtures before sodium refining. This minimizes sodium consumption. If necessary, xylene can be purified by itself.

For further information, send for the new U.S.I. technical data bulletin "Desulfurization of Benzene, Toluene and Xylene by Sodium." Address Technical Literature Department, U.S.I. Chemical News, 99 Park Avenue, New York 16, New York.

For commercial-scale processes developed by U.S.I., and for their costs, U.S.I. can put interested parties in touch with engineering companies who have developed plant designs for these processes.

Process Good for Many Hydrocarbons

Sodium desulfurization has also been used successfully with other hydrocarbons such as naphthalene. U.S.I. researchers have broad experience with this process, and will be glad to work with interested companies.

New Extinguisher Quenches Three Types of Fires

For the first time in history, a fire extinguisher has been developed which will put out all types of fires, according to recent reports. The extinguisher is said to do an effective job of quenching the three principal kinds of fires—those in combustibles like paper and wood, those involving flammable liquids like gasoline, and those in electrical equipment.

It uses a non-caking and moisture-repellent dry chemical which expands into a rubbery mass when exposed to heat. This action tends to smother the fire.

Up to this time the many kinds of fire extinguishers have been able to handle one, and sometimes two, classes of fires, but never all three. While the new extinguisher is claimed effective on all three, it does not supplant other extinguishers which may have superior quenching powers on a particular type of fire.

Rapid Chemical Reactions Analyzed by Photoflash

By exposing various materials to billion-watt flashes of light that last only a millionth of a second, chemists have recently observed many of the short-lived substances that play key roles in photochemistry, it is reported. Called "flash photolysis," the new analytical technique has already revealed the details of important chemical processes in areas ranging from inorganic chemistry to biology.

The technique employs a microsecond flash of strong light to start the reaction. Then, after an interval of a hundred thousandth of a second or less, the mixture is analyzed spectroscopically by a fainter burst of light. In this way, intermediate products with a lifetime of only a few millionths of a second have been positively identified, according to the report.

TECHNICAL DEVELOPMENTS

Information about manufacturers of these items may be obtained by writing U.S.I.

Patented process for making organic microfibers now being licensed. In process, vinyls, acrylics, nylon, polyesters, asphalt, etc., are melted or dissolved and sprayed to form superfine fibers. Suggested for filters, other uses. **No. 1620**

Variable programming systems, for automation of chemical analyses and procedures in clinical and biochemistry, now on market. Units include indexing, transfer, storage, centrifuging, incubating, programming mechanisms. **No. 1621**

Corporate diagrams and administrative personnel of the chemical industry are presented in new, looseleaf edition of reference book now being sold. Supplement also supplied to keep information up-to-date. **No. 1622**

Counter-current, liquid-liquid extractors for complex solvent extraction are described in new bulletin now available. Extractors incorporate several mixing and separating stages in single bowl revolving at high speed. **No. 1623**

How ammonium nitrate behaves under fire conditions is covered in new article which can now be purchased at nominal price. Conditions necessary for explosion are detailed, as are fire-fighting procedures and storage methods. **No. 1624**

POLYMER, a new international quarterly devoted to science of large molecules, is now offered on paid subscription basis. Provides medium for publication of original papers on chemistry, physics, applications of polymer research. Includes publicity on papers to come. **No. 1625**

Technique for producing flame-resistant urethane foam of polyester type is described in new bulletin now available. Reveals that additions of tris (beta-chloroethyl) phosphate (TCEP) to foam mix controls burning rate. **No. 1626**

New, low-cost infrared spectrophotometer makes possible high-resolution runs in near-infrared wavelength region between .83μ and 7.65μ. Gives exact structural information on organics with C-O and O-H molecular configurations. **No. 1627**

Alkaline electrocleaner, containing chelating agents, has been introduced for heavy-duty anodic cleaning of heavily soiled steel which has enough smut, rust or oxides to defy complete cleaning in conventional electrocleaners. **No. 1628**

Tantalum and niobium metallurgy are subject of recent book which can now be purchased. Covers extraction, reduction, consolidation, working. Includes chapters on physical, chemical, mechanical properties; corrosion; alloys. **No. 1629**

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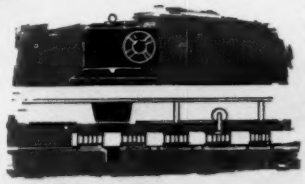
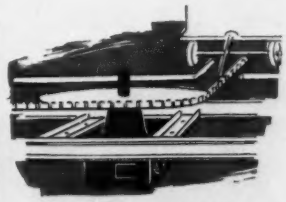
MORSE EBERHARDT-DENVER CONVEYOR DRIVES

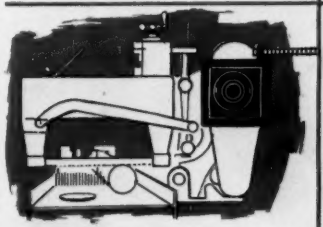
★ No design limitation . . . up, down, or 90° mounting ★ one-piece alloy cast iron housing ★ high torque capacity ★ single or double reduction gears ★ input ratings from .12 hp to 53.72 hp using double worm reduction or helical worm reduction ★ ratios from 5:1 up to 3600:1—from stock at low factory prices.



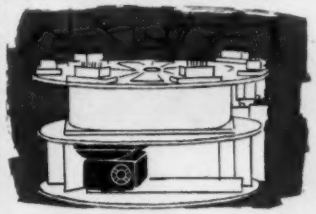
OVERHEAD . . . typical caterpillar or sprocket drives



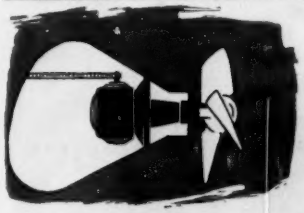
SUB-FLOOR . . . for towline or special equipment



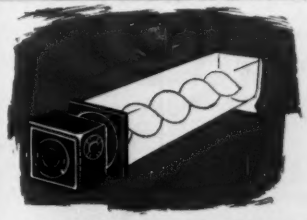
90° MOUNTING . . . for heavy-duty metal saws and machines



VERTICAL . . . base mounting for power turntable machines



SIDE MOUNTED . . . paint, pulp, liquid, or chemical agitators



HORIZONTAL . . . screw conveyors, straight or angular mounts . . . and scores of standard or special uses.

Easy-mount design . . . only 4 bolts

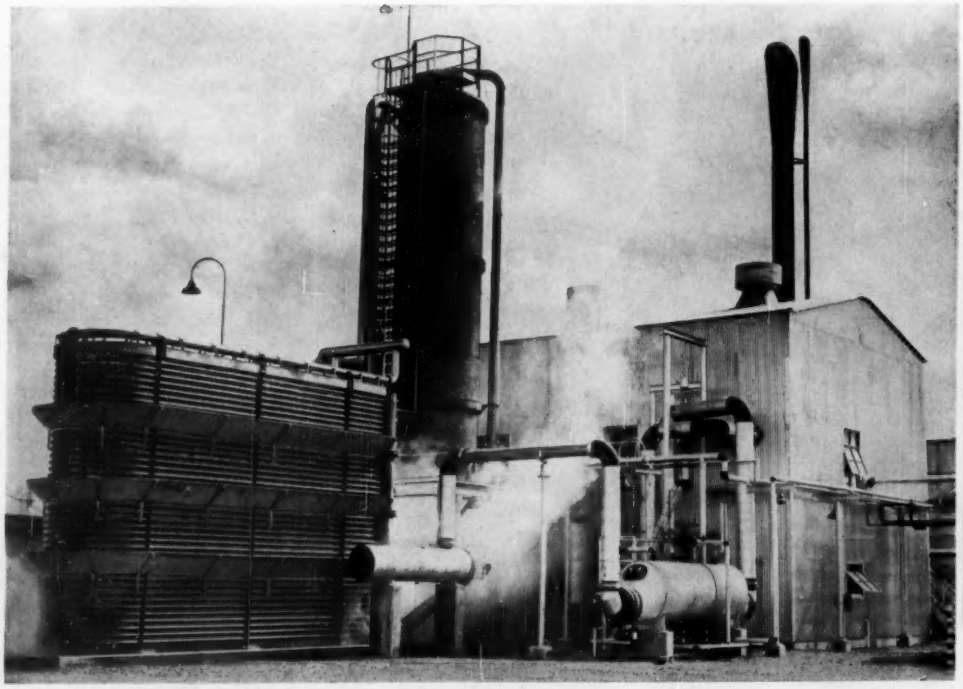
Morse E-D speed reducers lead in limitless applications with utmost ease in mounting. The 4 holes form a perfect square concentric to the output shaft. Unlike most designs, Morse E-D speed reducers feature oversize bearings on wide centers . . . resulting in an overhung load capacity at the end of the output shaft equal to the torque capacity.

Mounting versatility with the unit's cast-in base makes Morse drives adaptable to conveyors of all types, agitators, screw conveyors, machines, and for any other transmission of power where dependable speed reduction is specified.

You'll find Morse "standard" drives ready for immediate delivery . . . often eliminate the problems of "specials." Check with your Morse distributor, he's listed in the Yellow Pages under "Power Transmission," or write Morse Chain Company, Dept. 42-80, Ithaca, N. Y. for illustrated catalogs. In Canada: Morse Chain of Canada, Ltd., Simcoe, Ontario.

MORSE BW

A BORG-WARNER INDUSTRY

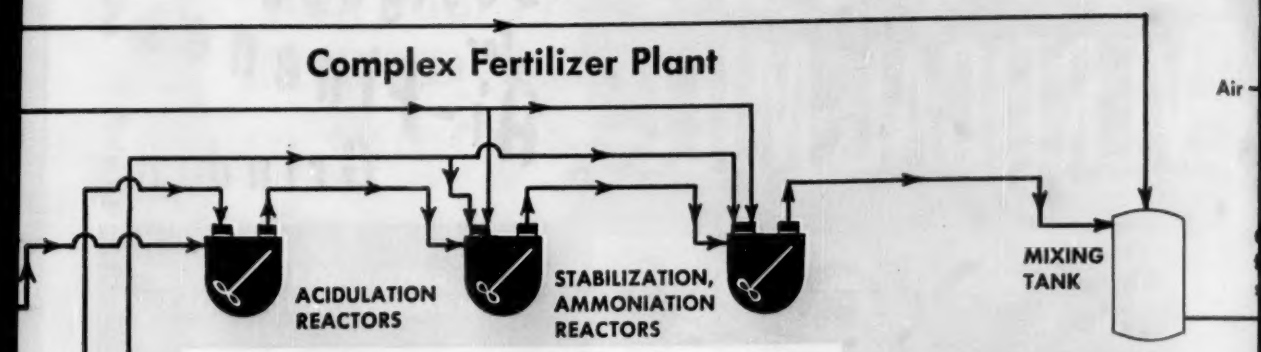


NITRIC ACID UNIT feeds both the ammonium nitrate and complex-fertilizer units.

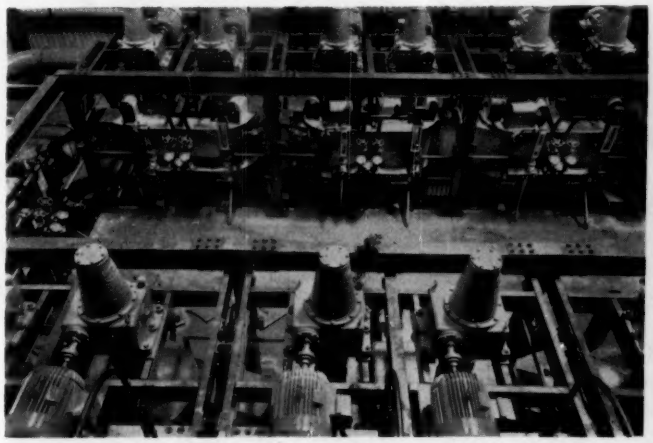
Two Fresh Approaches to Pelletizing

Latest fertilizer plant of California Spray-Chemical Corp. prills ammonium nitrate in efficient short tower, uses new spherodizer to simplify production of fertilizer pellets.

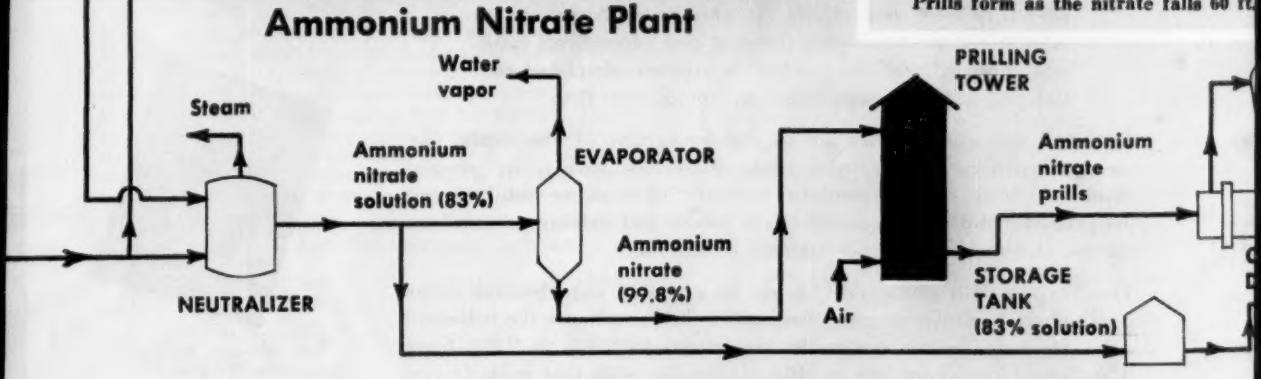
Unfold Flowsheet



▲ REACTORS like ones below combine prosphate rock with acids and ammonia. New plant uses ten reactors hooked in series.

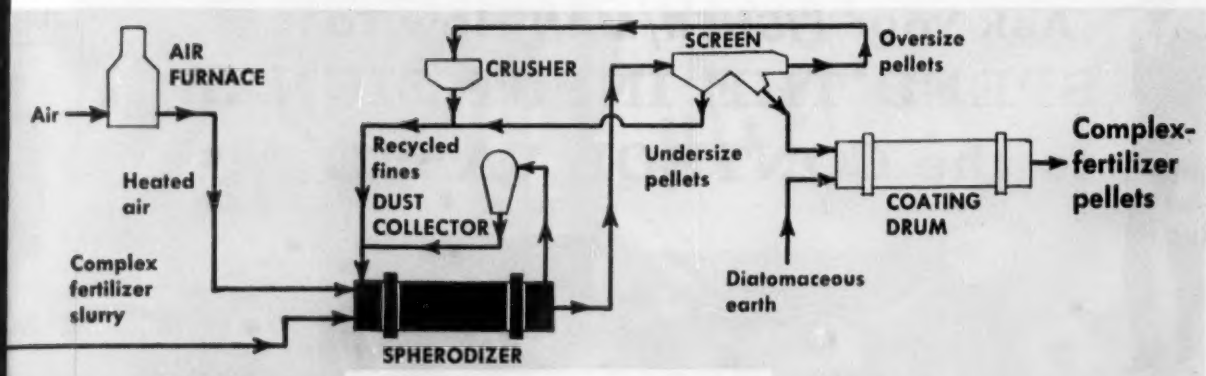


▼ PRILLING TOWER receives molten
Prills form as the nitrate falls 60 ft.

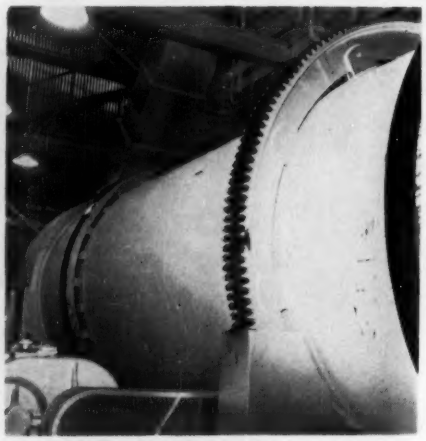


The usually prosaic operation of pelletizing had a double claim on the limelight when California Spray-Chemical Corp. formally opened its newest fertilizer plant at Kennewick, Wash., this spring. Basis for the two claims: a prilling power, considerably shorter than usual, which efficiently prills ammonium nitrate, and a new, short drum called a spherodizer which forms pellets of complex fertilizers and dries them at the same time.

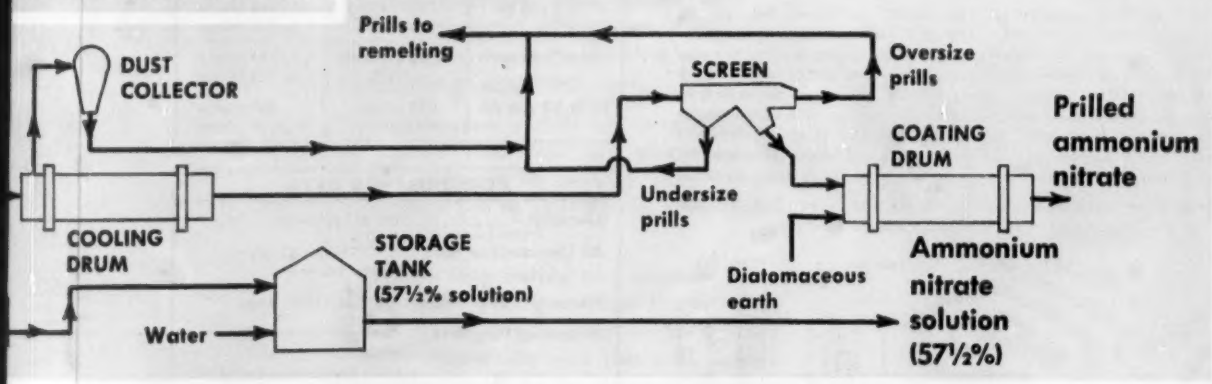
The new Calspray plant can turn out 150 tons/day of ammonium nitrate prills (or 200 tons/day of ammonium nitrate in solution), as



▲ **SPHERODIZER converts fertilizer slurry directly to dry pellets.**



molten 99.8% ammonium nitrate. ls 60 ft. through rising cool air.



drum
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well as 300 tons/day of complex-fertilizer pellets. In addition, it has a unit that can make some 200 tons/day of liquid fertilizers, plus a 150-ton/day nitric acid unit to provide feed for the rest of the plant.

The plant's requirements for anhydrous ammonia are supplied from a nearby operation of Phillips Pacific Chemical Co. Phosphate rock is shipped from Wyoming or Idaho, potash comes from California or New Mexico.

► **Almost New**—Both the spherodizer and the short prilling tower, developments of the Chemical

& Industrial Corp., Cincinnati, are newcomers to the industrial scene. C&I's short prilling tower made its first appearance in 1958, at Ketona Chemical Corp.'s ammonia nitrate plant in Ketona, Ala. The first installation of a spherodizer took place last year at the Salt Lake City, Utah, plant of Western Phosphates Inc., where it is used to pelletize ammonium phosphate.

▶ **Not So Complex**—The Kennewick complex-fertilizer unit is similar in many ways to one that Calspray built in 1956 at Richmond, Calif. Both produce complex plant foods by the PEC (Potasse & Engrais Chimiques) process, in which nitric acid rather than sulfuric acid acidulates phosphate rock feed. The new wrinkle at Kennewick is the use of the spherodizer to form pellets from the fertilizer slurry.

Big feature of the spherodizer is that it pelletizes the slurry and dries the pellets all in one operation. It boasts a very low recycle rate; C&I claims that only about 10% of the drum's output needs to be recycled. Its use does away with much of the materials-handling equipment generally found in a conventional granulating operation.

The spherodizer forms pellets by spraying finely atomized feed slurry through a falling shower of partially formed pellets inside the drum. The fresh slurry coats the pellets, making them larger. A stream of hot air, passing cocurrently through the drum with the slurry, dries the pellets as they are coated. Rotation of the drum picks up the pellets, thus provides a continuous shower of them. By the time they reach the discharge end of the spherodizer they have been coated sufficiently to be of product size.

▶ **Prills**—Although the prilling tower is the dominant feature catching a visitor's eye in the ammonium nitrate plant, it is only about one-third the height of conventional towers. The ammonium nitrate prills form during a drop of only 60 ft. The prilling tower is an innovation for Calspray, because its older plant at Richmond produces ammonium nitrate only in solution form.

Key to getting by with a short prilling tower is extensive pre-evaporation of the material to be prilled. In the C&I system the feed is concentrated in a falling-film evaporator to over 99.5% before it goes to the top of the tower, whereas older prilling arrangements evaporate the feed to only 95-96%. C&I claims that its system not only achieves solidification in a shorter tower but also provides prills that are superior in physical characteristics and nitrogen content.

▶ **The PEC Process**—Operation in the complex-fertilizer unit can be broken down into two major steps: chemical production of a fertilizer slurry, followed by conversion of the slurry to marketable pellets.

Production of the slurry takes place in a series arrangement of ten U-shaped reactors, which are provided with agitators and with jackets for water cooling. Ground phosphate rock is fed to the first reactor together with nitric acid, producing calcium nitrate and converting the phosphate content of the rock to soluble form.

In the downstream reactors, sulfuric and phosphoric acids and ammonia are added. These react with the acidulated mixture, and the resulting slurry consists of ammonium nitrate, dicalcium phosphate, other compounds and impurities introduced with the phosphate rock. Proportions of these compounds depend on the fertilizer formulation being prepared. In any case, enough acid is added in the downstream reactors to completely convert the calcium nitrate which formed during the original acidulation. (Reason: calcium nitrate is very hygroscopic, would cause handling problems if it appeared in the final product.)

One of Calspray's solid complex fertilizers contains potash. When this product is made the potash is added at the end of the above reaction sequence, to avoid corrosion problems that can result from mixing the chlorides in potash with nitric acid.

▶ **Making Pellets**—After reactions are completed the slurry goes to the spherodizer, together with air which has been preheated to about 400 F. in a furnace. The spherodized material is led to screens for separation of undersize and oversize. The oversize is crushed, and it and the undersize return to the spherodizer.

Pellets not rejected by the screens go to a rotary drum, where they are coated with diatomaceous earth to improve handling properties. The product from the coating drum is ready for bulk storage and bagging.

▶ **Ammonium Nitrate**—The ammonium nitrate process is less involved, and substantially all of it takes place in or around the prilling tower. First step is a neutralization reaction between anhydrous ammonia and nitric acid, which enters from the nitric acid unit as a 57% solution.

Heat of reaction boils off much of the water, and the product stream is an 83% solution of ammonium nitrate. About one-third of this stream is tapped off to a storage tank, then diluted for sale as 57½% (or 20% nitrogen) ammonium nitrate solution.

The rest of the stream goes to the evaporator. Evaporator product is 99.8% ammonium nitrate, which is kept above 300 F. and pumped to the top of the prilling tower. Prills form as the material drops 60 ft. through a rising current of cool air.

Prills from the bottom of the tower pass through a cooling drum and on to screens. Oversize and undersize prills are recycled; the acceptable prills pass through a diatomaceous-earth coating drum and on to bagging.

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B&W's complete range of sizes, grades and types of stainless steel pressure tubing provides you with . . .

- the choice of a specific tube which best meets a given set of service conditions
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The availability of *the best tube for the job* is only one of the reasons why it pays to specify B&W Job-Matched Stainless Steel Tubing. It permits freedom of design, and optimum low cost as well as long service life. Many sizes, grades and types of B&W Stainless Tubing are available through your local Steel Service Centers. For additional information call your regional B&W District Sales Office or write for Bulletin TB-1. The Babcock & Wilcox Company, Tubular Products Division, Beaver Falls, Pa.

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Ask Your *FISHER/MAN* How To

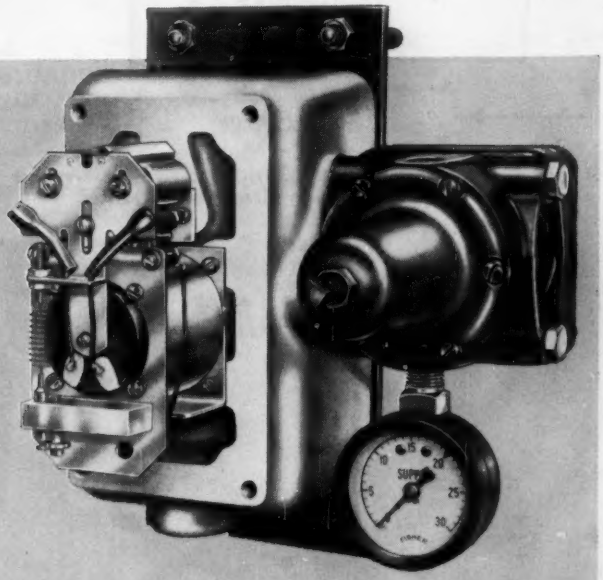
SPEED THE INPUT SIGNAL to the CONTROL VALVE

FISHER

TYPE

543

ELECTRO PNEUMATIC TRANSDUCER



Available with or without a pneumatic valve positioner

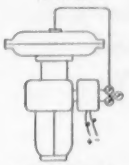
Here's an electro-pneumatic transducer developed for use in electrical control loops where the final control element is pneumatically operated. Explosion proof design makes it ideal for use under hazardous conditions. Input signals may range from 1 to 5 ma. through 10 to 50 ma.... output from 3 to 15 psi through 6 to 30 psi. Built-in volume relay permits direct operation of the pneumatic actuator from the Transducer. No extra relays or boosters needed. Relay can be serviced independent of electrical assembly. Unit is completely reversible by reversing input leads and rezeroing.

If you want additional information on the Type 543 Electro-Pneumatic Transducer write Fisher Governor Company.

TYPICAL CIRCUITS		
Input Current	Load Requirements of Controller	Actual Internal Resistance of Transducer
1 to 5 ma dc	3,000 ohms maximum	2,500 ohms ±125 ohms
1 to 5 ma dc	12,000 ohms ± .5%	12,000 ohms ± 50 ohms
10 to 50 ma dc	500 ohms maximum	57 ohms ± 4 ohms

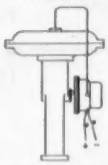
PERFORMANCE DATA	
Linearity	1% of full range
Air Consumption Rate	2 SCFH with 15 psi output pressure
Resolution Sensitivity	.05% of input range
Frequency Response	Complete frequency response data with Fisher topworks available

TYPE 3541



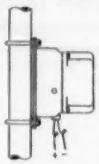
Electro Pneumatic Controller Mounted on Control Valve

TYPE 543



Transducer Mounted on Control Valve

TYPE 543



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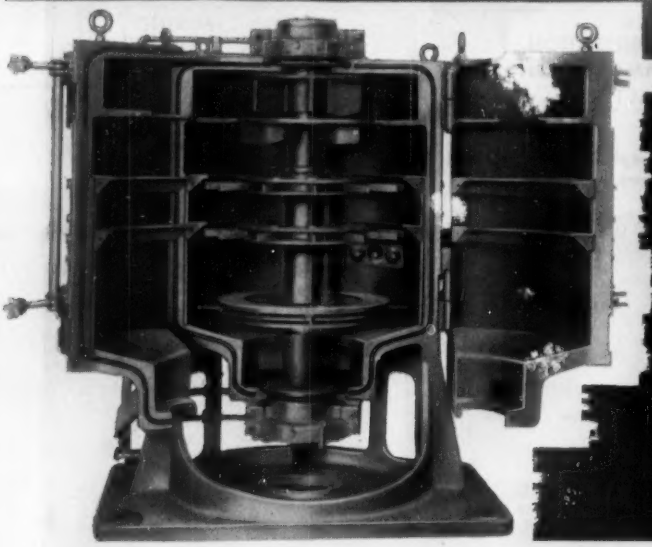
RAYMOND VERTICAL MILL

Designed for Hi-Fineness Grinding



HEAVY ROTOR SHAFT CARRIES FAN, HAMMERS AND WHIZZERS

WIDE HINGED DOORS FOR EASY ACCESS

WHIZZER AIR SEPARATION PRECISION CONSTRUCTION

SIMPLIFIED DESIGN WITH NO CLOSE CLEARANCES

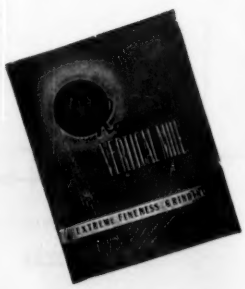
QUICK SET-UPS AND EASY ADJUSTMENTS

Here is a modern mill so efficiently designed for its purpose that it is establishing records in the economical production of extremely fine materials in the sub-sieve particle sizes.

The prime features of the Raymond Vertical Mill are simplicity and accessibility. It permits quick set-ups to minimize down-time—easy cleaning and adjustments facilitate changes from one product to another—simplified control and automatic operation save production time.

This unit has wide application to a great variety of chemicals, pigments, synthetic resins, phosphate materials and many special products. It is serving modern industry in making solid rocket propellants, and it does an excellent job in pulverizing ammonium nitrate and ammonium perchlorate oxidizers.

The Vertical Mill gives good results in grinding non-abraisve materials to high fineness ranging from minus 325 mesh into the sub-sieve sizes. On some softer materials, reductions to 95% to 98% finer than 5 to 10 microns are readily obtainable with this mill. *If you have a hi-fineness grinding problem, write us for detailed information.*



Raymond Bulletin No. 78-E gives full details of superfine grinding operations. Write for your copy today.

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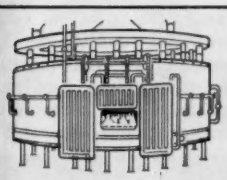
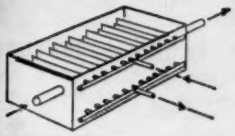
ALL TYPES OF TANK AND PROCESS HEATING AND COOLING



OVEN AND FURNACE USES

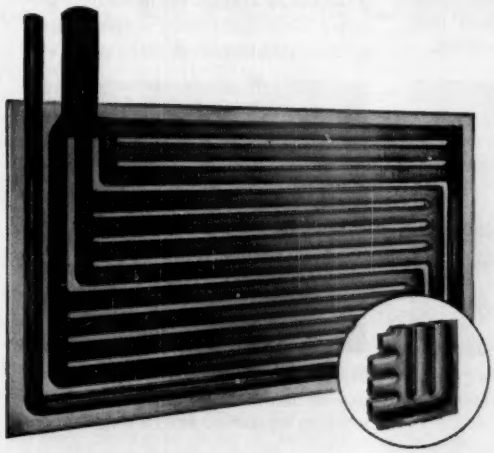
EXTERNAL OR INTERNAL MOUNTING



WASTE HEAT RECOVERY

PLATECOIL is the versatile, factory fabricated answer to heat transfer problems of all kinds. You can apply PLATECOIL to all types of tank and process heating and cooling — open tanks, closed tanks, agitated tanks, deep tanks, jacketed tanks, sumps, kilns, ovens and many others. Basic PLATECOIL types include header and serpentine designs in single embossed, double embossed, flat, rolled and banked units. They are available in mild steel, stainless steel, Monel, Ni-o-nel, Hastelloy B, Hastelloy C, nickel, and many other metals. Special designs, surface finishes, structural parts and connections add to their versatility. Operating pressure now rated up to 250 psi.

NEW MULTI-ZONE* PRINCIPLE PRODUCES MORE EFFECTIVE HEAT TRANSFER



Multiple headers with multiple condensate returns provide better steam distribution and more total effective heat transfer area in the new MULTI-ZONE PLATECOIL. FREE-FLO action, without condensate trapping increases processing production through faster "start-up" and extremely fast temperature recovery. This reserve capacity also holds temperature variations to a minimum. PLATECOIL eliminates problems of engineering, fabricating, installing and maintaining pipe coils. PLATECOIL units are lightweight and easy to handle. They are compact and save tank space. Deposits do not build up on streamlined PLATECOIL surfaces as they do on pipe coils. All stainless steel and alloy PLATECOIL units affected by cold working are annealed and pickled after fabrication to return the metal to its original condition and thus eliminate the probability of corrosion due to internal stresses and carbide precipitation. PLATECOIL is also relatively simple and economical to remove, clean and re-install. In most cases there is no need for threaded joints within the solution to corrode or leak.

Investigate the possibilities of PLATECOIL for your specific problem.

*Patented

Send for Bulletin P61 for more data.

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on Services and Products in Stock

In addition to the products shown below, you can call on Ryerson for flame-cut steel shapes, fabricated steel for reinforced concrete construction —many other products and services. And equally important are the specialists who carry out the Ryerson quality control program—see that customers specifications are *exactly* met, that every order is correctly filled and promptly delivered. As a result you get unequalled service and certified quality when your company calls Ryerson for steel, aluminum, industrial plastics and machinery.

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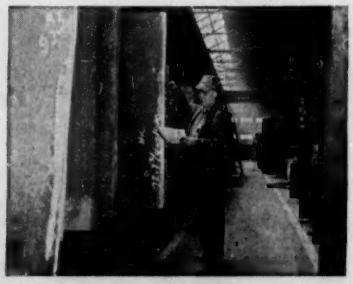
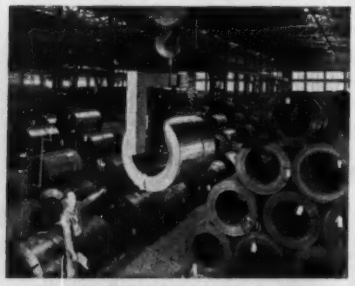
Most complete range of types, shapes and sizes as well as largest tonnage.

STRUCTURALS—I-beams, H-beams, channels, angles, tees and zees—all high quality steel to ASTM spec. A-7.

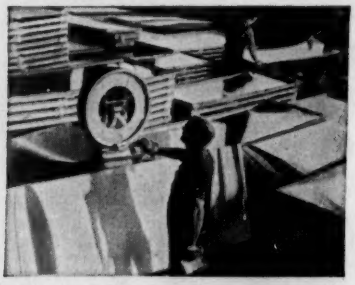


PLATES—14 types including special low carbon steel plates for forming and welding, leaded New E-Z-Cut, etc.

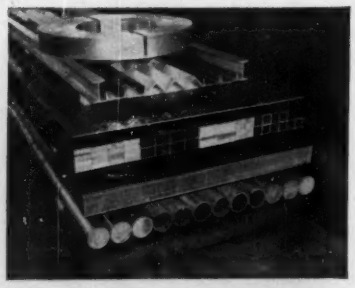


SHEET STEEL & STRIP—More than 20 different types in pattern sizes, cut-to-order sizes, strip coils, etc.

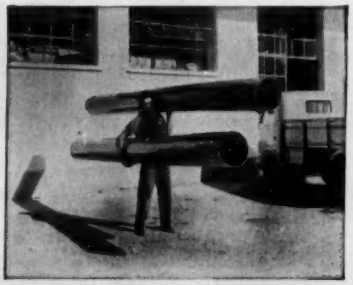
TUBING—Seamless and welded steel tubing—mechanical tubing, fluid line, pump cylinder and structural tubing.



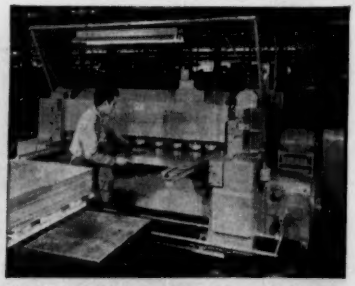
STAINLESS STEEL—For immediate delivery. Over 2351 sizes, shapes, types, finishes: sheets, plates, bars, pipe, etc.



ALUMINUM—At many Ryerson plants —sheets, coils, plates, bars, tubing, architectural and structural shapes, etc.



INDUSTRIAL PLASTICS—PVC pipe, fittings, sheets and rods, rigid Kralastic and flexible polyethylene pipe.



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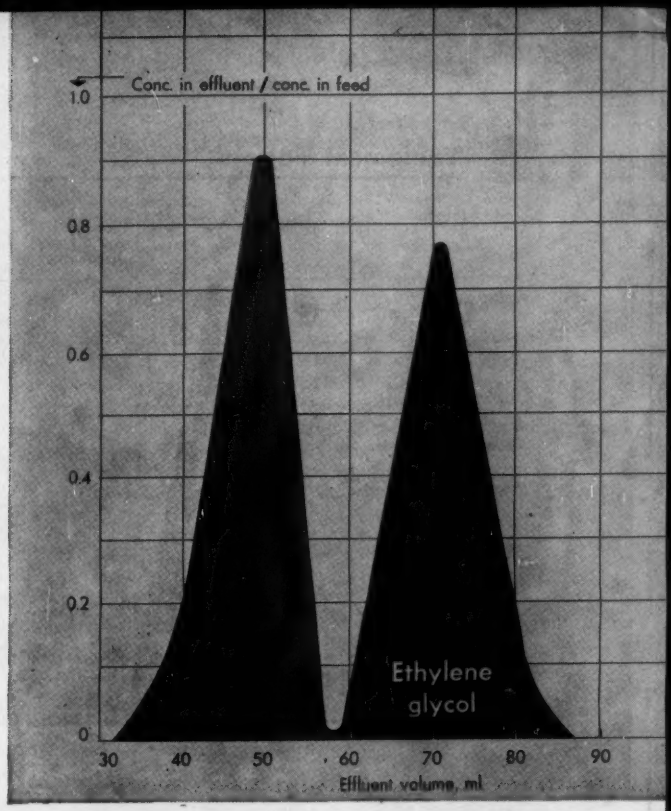


Sharp separation via ion exclusion—Fig 1.

Ion Exchange Becomes Powerful Processing Tool

Applications for ion exchange outside the water-conditioning field are increasing by leaps and bounds, due to "tailor-made" resins and improved technology.

A. H. Seamster and R. M. Wheaton, Dow Chemical Co., Midland, Mich.

If you are involved in chemical processing or manufacture, chances are that ion-exchange resins can be profitably incorporated into your process.

Long considered to be useful only in water conditioning, these resins now do a wide variety of jobs in handling both ionizable and non-ionizable compounds in the areas of separation, recovery, concentration, catalysis and many types of synthesis.

These applications outside of the water-treating field are increasing rapidly and are expected to become the major outlet for ion-exchange resins in the not-too-distant future.

One reason for this continued growth is constant development of new ion-exchange materials, tailor-made for specific uses (44 varieties are offered by one manufacturer). Another reason is increased knowledge of the properties of these very versatile materials (1,500 articles published in 1958 alone).

In serving as an introduction to the use of ion exchange in chemical processing, we will cover the nature and properties of ion-exchange resins, types of uses, process-equipment design factors, and costs of process plant equipment and operation.

Special Class

Ion-exchange resins are a special class of polyelectrolytes, rendered grossly insoluble by cross-linking into three-dimensional networks.

They contain a high concentration of fixed, solid, ionic species (R^+ or R^-),* plus smaller counter ions (C^+ or A^-) such as H^+ or OH^- which are free to move throughout the resin's structure, or even beyond in the presence of an external electrolyte solution. Ion-exchange resins are well defined solid structures ranging in size from 10 to 400 mesh. They are all highly hydrophylic, but water content varies greatly with degree of cross-linkage.

A cation exchange resin contains the small, mobile ion as a cation and it is written R^-C^+. Similarly, an anion-exchange resin is R^+A^-. In succeeding references to the resin matrix, charge will not always be shown, thus R instead of R^+ or R^-.

Important Properties

Properties of ion-exchange resins which impart their unique behavior include the following:

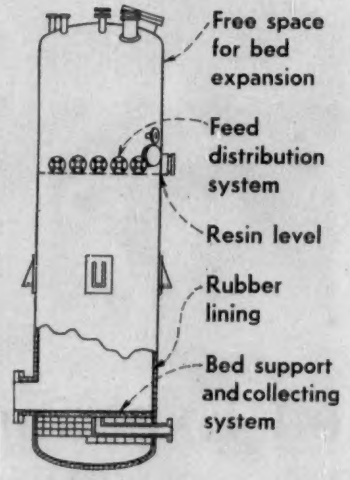
1. Structures are essentially ho-

* P^-, for example, can be the product of sulfonation of styrene-divinylbenzene polymer, R^+ a quaternary-ammonia styrene-divinylbenzene.

Types of Ion-Exchange Contractors—Table I

Type	Feed	Applications	Remarks
Batch reactor	Batch	Very high selectivity, neutralization	
Fixed bed column	Batch	General low solids	
Mixer-settler: resin retained in basket	Continuous	Slurries high selectivity	R.I.P. process
Mixer-settler: resin transfer by air fluidization	Continuous	Slurries high selectivity	Inflico-Techmanix
Moving bed: resin transfer by liquid pulsation	Semi-continuous	General	Higgins, resin upflow
Moving bed: resin transfer by liquid pulsation	Semi-continuous	General	Weiss, resin downflow
Moving bed: resin transfer by liquid pulsation	Semi-continuous	General low solids	Porter, resin downflow

Careful Column Design Yields Dividends—Fig. 2



mogeneous. Despite considerable misconception, ion-exchange resins contain reactive groups throughout the entire structure. However, there are locales of different composition resulting from tie-in of cross-linkage bonds and the randomness of polymerization.

2. In polar liquids, ion-exchange resins swell to form gel structures containing a well-defined quantity of liquid. The quantity of water sorbed is an exact reproducible value. Moisture content varies inversely with cross-linkage and electrolyte concentration. Ionic form is another determinant factor.

3. Though necessarily grossly insoluble, the gel has properties which are essentially those of a solution, modified only by the constraints of the cross-linking network.

Gross insolubility of an exchanger is a prime requirement, for much of its value comes from repeated re-use. However, the behavior of ion-exchange resins is best understood by considering the swollen resin particle to be a concentrated polyelectrolyte solution bounded by a permeable membrane.

4. The electrolyte ion which is not affected by the resin has a higher concentration outside the gel than inside, at equilibrium. This supports the model of a polyelectrolyte solution surrounded by a permeable membrane. Concentration-difference ratios become less at higher concentrations. Amphoteric, or ion retardation, resins are an exception to this rule, showing an affinity for the extraction of salts from solution.

5. Ion-exchange reactions are reversible. They, therefore, can be re-used repeatedly since there is no substantial change in the structure of the ion-exchange resin. If the equilibrium constant, K, is a large number, the reverse reaction is much less efficient than the forward reaction, requiring large excesses of regenerant chemical for moderate regeneration levels.

For nonexchange sorptive processes such as ion exclusion, K is defined as the ratio of solute concentration within the gel structure to the concentration outside.

6. Over-all exchange rates may be influenced by changes in solvent nature and content, particle size, temperature, and the kind and concentration of the functional groups.

Exchange rates are most rapid in polar systems and with resins with fewer cross-links because of the higher moisture content. Film diffusion becomes rate controlling at low concentrations and is inversely proportional to particle diameter. Particle diffusion controls rates at high concentrations and is inversely proportional to the square of the particle diameter.

The kind of functional group and its degree of dissociation under a given set of conditions greatly affect exchange rates where particle diffusion is controlling, but have no effect on film diffusion.

7. Ion-exchange materials have physical and chemical limitations beyond which it is not practical to operate. Extremely strong oxidizing agents such as boiling nitric acid or chromic-nitric acid mixtures will rapidly degrade the polymer matrix.

Operating temperatures below 150 C. are usually recommended; below 50-60 C. for highly alkaline operations with strong base exchangers.

The ability of resins to stand loss by attrition depends on their inherent strength, internal structure and operating conditions. High flow rates, turbid feeds, very deep beds and movement through improperly designed pumps and valves, all contribute to resin disintegration.

8. Specific properties of prime importance in an ion-exchange resin:

- Functional group, cationic or anionic, strongly or weakly ionized.
- Capacity (total). Units of exchangeable ions per unit volume or weight. Capacity (operating). Effective use of exchanger operating at a given set of conditions.
- Cross-linkage. Degree of

bridging built into polymer matrix or subsequently added or reduced determines water content which varies inversely with cross-linkage. Affects equilibria, kinetics, physical properties.

• Particle size. Determined by polymerization method and/or subsequent grinding and/or screening. Coarse sizes give best hydraulic properties (lowest pressure drop, lowest backwash expansion); fine sizes give best efficiency (best separations; lowest HETP).

Types of Uses

Ion-exchange uses may be segregated into principle categories as follows:

Removal of Ions—Ions in a solvent system can be removed by exchangers that produce a slightly dissociated product in their stead.

$$RH^+ + NaOH \rightarrow RNa^+ + H_2O$$
$$RAg^+ + NaCl \rightarrow RNa^+ + AgCl$$

Interchange of Ions—One ion in solution can be exchanged for another of like sign on the resin, to alter quality or kind of solution or resin.

$$2RNa^+ + Ca^{++} \rightarrow R_2Ca^{++} + 2Na^+$$

Concentration—Ionic materials, present at low concentration in solution, can be sorbed on the resin and subsequently eluted at a relatively high regenerant concentration.

$$\text{Sorption} \quad 2RH^+ + Zn^{++}(0.001M) \rightarrow R_2Zn^{++} + 2H^+$$
$$\text{Elution} \quad R_2Zn^{++} + 2H^+(10M) \rightarrow Zn^{++}(10M) + 2RH^+$$

Chromatography-Fractionation—Broadly applicable to all ion-exchange column operations, these processes are generally applied to the fractionation of multicomponent mixtures into their component parts:

Elution chromatography is a fractionation method in which the displacing ion is less strongly held by the exchanger than the ion to be separated, resulting in a gradual movement of ions through a column with simultaneous fractionation. Excellent separations are thus obtained but at the expense of dilution and contamination with the eluent. An example would be HCl used to elute a mixture of sodium and calcium chlorides on the resin. Sodium chloride elutes first, followed by calcium chloride, both mixed with hydrochloric acid.

Displacement development involves a situation where the incoming species is more strongly held by the resin than the initial ions to be separated. Preferred for gross separations, there is little dilution and contamination, though inherently more contamination than with elution chromatography.

Frontal analysis is a term used when feed solution is continuously introduced to a resin column until appearance of an undesirable constituent in the effluent. This method is useful for fractionation only when the strongly held component is present in minor proportion.

Ion retardation involves use of specially synthesized amphoteric ion exchangers incorporating both anion and cation groups.[1] It is then possible to separate an electrolyte (C^+A^-) from a nonelectrolyte (N) by elution chromatography using water. The electrolyte is preferentially sorbed to retard its passage through a resin column and to permit the prior elution of the nonelectrolyte.

$$R^+ \cdot R^- + C^+A^- \rightleftarrows R^+A^- \cdot C^+R^- \quad K_1$$
$$R^+ \cdot R^- + N \rightleftarrows R^+ \cdot R^- \cdot N \quad K_2$$

Here K_1 is greater than K_2.

Anion-Sulfate Process — This

Ion Exchangers:

Design

Recommendations for Fixed-Bed Supports—Table II

General Requirements	Types of Underdrain Systems
Chemical stability.	Graded subfill—quartz, anthracite coal, sand or gravel; in large units, perforated pipe laterals are used in combination with subfill.
Physical stability.	Perforated plate.
Uniform porosity.	Porous filter medium.
Low-pressure drop.	Slotted pipe.
Non-sorbent for compounds to be handled.	
Low maintenance cost.	

Scale-Up Data for Ion Exchange Design—Table III

Resin Bed (Lab Unit)	Process Streams (Lab Unit)
Resin-type, crosslinkage, particle size.	Feed—concentration, volume, flowrate.
Resin life.	Regenerant—kind, concentration, volume, flowrate.
Resin bed dimensions—hight, diameter.	Water rinses—volume, flowrate.
Resin bed performance curves.	Waste—concentration, volume.
	Operating temperature.
	Methods of analysis—especially for process control.

Guides for Designing Ion-Exchange Columns—Table IV

Flow Rates	Gpm./Ft.^{2}
Water softening or deionization	2–10
Regeneration	0.5–2
Recovery and conversion	0.5–2
Water rinsing	0.5–2
Ion exclusion	0.5–1

Usual Regenerant Quantities	Lb./Ft.^{3}/Cycle
HCl	4–10
H_2SO_4	6–8
NaOH	4–8
NH_3	2–4
NH_4Cl	5–10

Pressure Drop, Psi./Ft. Resin	
50–100 mesh	Flow rates as gpm./sq. ft.
20– 50 mesh	1/12 flow rate as gpm./sq. ft.

Column Dimensions
Bed diameter—Experience to 20 ft.
Bed height—Usually 5 ft., but no limit.
Dome height—Based on type of resin usually 50–100% of bed height.

process,[3] useful for removing H_2SO_4 from a solution of metal salts or nonionic species, depends on (1) dissociation of H_2SO_4 to HSO_4^- and SO_4^- as a function of concentration and (2) selectivity of a strongly basic anion exchange resin for sulfate vs. bisulfate ions. Thus, H_2SO_4 may be removed from solution at high concentration by conversion of the resin to the HSO_4^- form, yielding an acid-free product. The resin in turn may be water-rinsed for regeneration.

$$H_2SO_4 + N + R_2SO_4 \rightarrow 2RHSO_4 + N$$

Chelation—Use of a special resin containing a chelate-forming structure makes possible removal of metal ions which complex-forming tendencies.[3]

There are, in addition, a number of uses, not principally ion exchange, for these ion-exchange materials.

Aldehyde Removal — Aldehydes[4] may be taken from aqueous solution by use of quaternary ammonium resins in the bisulfate form through the well-known bisulfite addition reaction of organic chemistry.

Ion-Exchange Catalysis—By direct analogy with classical chemistry, either the functional group or the mobile ion of an ion exchanger may serve as a catalyst for a chemical reaction.[5]

In general, a strongly acidic resin in its acid form may be substituted for hydrochloric or sulfuric acid with the added advantage of being easily filtered from the reaction mixture for re-use. Most promising large-scale applications are olefin epoxidation, hydrolysis and esterification reactions. Other ionic forms of several resin types may be of use.

Ion Exclusion—An elution process, ion exclusion[6] is useful for separating ionized materials from preferentially sorbed non- or slightly ionized materials when both are present in aqueous solution. Ionic solutes, due to the permeable membrane effect, exist at a lower concentration within the resin gel than in the surrounding solution. At the same time, nonionic solutes of low molecular weight are, as a first approximation, equally distributed between the two phases. Thus, if a solution containing ionic and nonionic components is placed on top of a bed of resin and forced down through the column with water, the ionic material will be eluted first since it only has to displace the solution in the voids. The nonionic solution must displace both the liquid in the void and resin liquid and will appear in the effluent after the ionic material has passed out of the column (see p. 115).

Nonionic Separation — Distribution of an organic solute between the void liquid phase and the resin liquid phase may differ appreciably from one organic solute to another.[7] Sugar, for example, is largely excluded from the resin-liquid phase whereas phenol is strongly sorbed. It is thus possible to separate many water-soluble organic materials simply by "washing" them through a column of ion-exchange resin with water. Many modifications of this concept are being developed, such as salting-out chromatography.[8]

Phenol Concentration — Strongly basic anion-exchange resins have a particularly high capacity for phenolics over and above the true ion-exchange capacity. This is because of sorptive effects.[9] The distribution of phenolics in a water-phenolic-resin system is quite different from that in an alcohol-phenolic-resin system. This difference makes it possible to extract phenols from aqueous media, to concentrate them on the resin, and then recover the phenols at higher concentrations in the alcohol phase. This may be accomplished without consuming chemicals other than the solvent.

Great Number of Devices

With the expansion of ion-exchange uses in the chemical processing field, many new and specialized conditions are encountered. This has resulted in a large number of proposed devices for contacting liquids and resins. The contactors that have been accepted or are in the advanced development stage are listed in Table I.

Good examples of equipment designed to fit special process requirement are the many mixer-settler contactors such as Infilco's Techmanix,[10] and the R.I.P.[11] process in which resin is confined in a wire basket. Both are used for contacting resin with slurries.

Three fairly new contactors, the Higgins,[12] Porter[13] and Weiss[14] units, are expected to answer the demand for a continuous countercurrent contactor. All move the resin in intermittent flow through the contacting zone and are thus semi-continuous, but for all practical purposes can be considered continuous.

Perhaps the simplest contactor in principle is the batch reactor or single-stage contactor. In this unit, resin is intimately mixed with the liquid to be treated for removal of the unwanted ions. There are two general requirements for this type of operation: (1) that the reaction goes essentially to completion with little excess resin, as determined by equilibrium constants, and (2) that the quantity of materials such as catalysts to be removed is low, since the resin may be discarded after use.

In addition, there are processes where variations of the above techniques have been used. Such an operation is carried out in some uranium mills in which elution of uranium takes place in a fixed-bed column to which the resin has been transferred from the loading column. In another instance, resin loading is carried out in a stirred reactor above a filter bed which later serves as a supporting bed for fixed-bed column elution.

Fixed Column Design

Fixed-bed column contactors can be as small as a few inches in diameter and a few feet in depth, as in the home water softener, or as large as 20-ft. in diameter on industrial units with single column bed heights up to 20 ft.

Multiple column bed heights of over 100 ft. are used in rare earth separations. Since this type of contactor is the only one currently in wide general use, it will be covered in detail in this article.

Details of a typical fixed-bed column are shown in Fig. 2. Essential requirements are (1) space above the resin bed, (2) liquid distribution system, and (3) a bed support and collecting system.

Space above the resin bed allows for bed expansion during backwash operations to loosen and reclassify the bed and to remove extraneous materials. It is occupied by water in a water-dome system or air in an air-dome system.

The drawback of a water-dome is the possibility of diffusion into the dome water with resulting product dilution and poor separation. How-

ever, the merits of one over the other are not clear-cut. For instance, in the Blind River, Ontario, uranium ion-exchange plants, the first units used air-dome to avoid diffusion. But this was not found to be a problem and all subsequent plants have used water-dome, which is cheaper and easier to operate.

Distribution of the feed and the regenerant in ion exchange across the bed is usually accomplished by perforated pipe-laterals. The holes are made sufficiently large so that any resin entering the laterals during backwash will wash out when flow starts through the distributor. The holes may be covered with screen to exclude the resin, but a disadvantage would be plugging on the back-side from foreign solids in the feed.

Air or Water Dome

An air-dome system using a spray-nozzle as a distributor has proved to be quite successful on both 8-ft. and 12-ft.-dia. columns used for ion exclusion where flow rates do not change during the process. Here a 1-in. liquid level is maintained above the resin to protect the resin surface from being disturbed.

The bed support and collector system are important to obtain the proper flow distribution through the bed for both downflow and upflow operations. General requirements and types of underdrain systems are shown in Table II.

Where small feed volume to bed volume is encountered such as in ion exclusion and most chemical applications, perforated plate or porous media[18] are recommended.

Operation of the fixed bed can be controlled manually or automatically.

On a water-dome, a sequence timer is used for controlling the various cycle steps such as feed, water rinse, regeneration, etc.

Flow through the bed is controlled by a flow recording controller which is reset by the timer to obtain the desired flow rate for each stream.

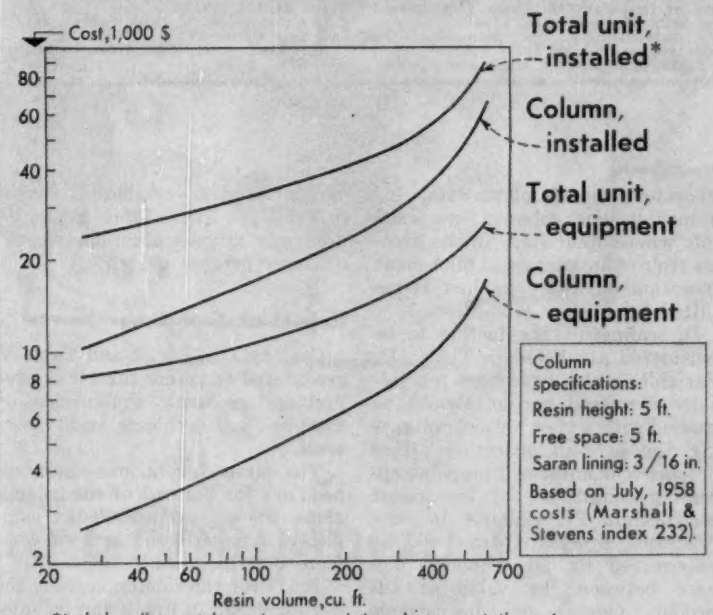
In completely automatic operation, it is usually advisable to control the separation of the product fraction from the bed effluent by measuring a chemical or physical characteristic of the product such as conductivity, refractive index, density, pH, etc. This will take care of fluctuations in feed composition, flow rate or bed performance and in addition, if recorded, will prove invaluable when interpreting the bed performance.

A control system suitable for air-dome operation is similar except for a liquid-level controller which holds the liquid level above the resin and a pressure-recording controller which maintains the desired head on the column.

How to Scale Up

For fixed-bed column operations it is recommended that the plant size unit be scaled-up directly from

What It Costs to Build and Install Ion-Exchange Units—Fig. 3



*Includes all material, equipment, piping, instrumentation, etc. installed for a complete unit. Contains all direct and indirect costs except for the resin.

Plant Operating Experience—Table V

Column No.	Dia. × Ht., Ft.	Type	Cycle Time	Resin Life	Resin Makeup	Degree of Automation	Operating Man-Hr./Shift
10	12¾ × 5	I. X.*	3 days	Over 5 yr.	Nil	Automatic	8
1	9 × 5	I. X.*	2 hr.	Over 5 yr.	1.3%/mo.	Automatic	1–2
1	7 × 5	I. X.	3 hr.	9 mo.	Nil	Semi	8
1	8 × 8	I. E.†	3 hr.	Over 5 yr.	0.9%/mo.	Semi	6
1	12 × 8	I. E.	3 hr.	Over 5 yr.	0.9% mo.	Semi	6
1	5 × 12	I. X.	12 hr.	3 mo.	Nil	Semi	6
8	5 × 12	I. X.	48 hr.	Over 1 yr.	Nil	Semi	8

* Ion exchange † Ion exclusion

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laboratory or miniplant data. Intermediate-size columns are used only where other steps in the process require an integrated pilot-plant operation or where product is required for market evaluation.

In scaling-up, the factors to be considered are listed in Table III. Variables which have been individually discussed earlier should be studied with a view toward optimizing the over-all operation. Here process economics will pinpoint operating conditions for the lowest cost design. For example, in some processes, product volume will be determined by an economic balance between the value of the product (yield) and downstream processing costs (product concentration).

In any case, prior to the final plant design, ion-exchange units at least 1-in. in diameter and of the proposed bed depth should be operated exactly as proposed. The same operations may be expected on scale-up regardless of diameter (experience to 20-ft. in diameter). Sizing of the plant unit is then very simple. The steps involved are:

- Calculate a material balance for unit bed volume from laboratory data.
- Scale-up the process streams and the resin volume to fit the required feed or product rate. This specifies the column diameter.
- Bed height and cycle time are the same as the small scale unit.
- Total column height is set by adding sufficient height to the resin bed depth for backwashing the bed. Equilibrium expansion data are available for most ion-exchange resins from which the backwash height can be determined.[16]
- Pressure drop across the bed for various flow rates and resin particle sizes can be calculated accurately enough for design purposes from equations for flow through packed beds. Experimental data are also available.[16]

The usual operating range of various process variables is shown in Table IV. These values are to be used only as general guides in preliminary process design.

Important Cost Data

Cost data in Fig. 2 and Table V are offered as guides for use in preliminary economic evaluations of fixed-bed ion exchange resin processes.

The curves for various-size resin beds are for the cost of the column alone, the column installed, a completely automatic unit and the complete unit installed.

Basis for the column costs is the design shown in Fig. 2 and includes stainless steel pipe-type distributors, $\frac{1}{8}$ in. Saran rubber-lining, a Dow porous supporting media, plus necessary nozzles, etc.

Installed costs were determined by multiplying equipment costs by an installation factor.

How the initial resin cost is handled depends on the expected resin life. Normally resin life is long enough so the initial resin charge can be considered as a direct capital cost and added to the installed equipment cost. Resin make-up is then handled as a raw-material cost. When severe resin attrition is expected, the resin is then considered as a process raw material.

There appears to be no correlation between operating manpower requirements and number or size of columns, cycle time, or degree of automation. This is because of factors such as value of product and availability of other work in the immediate area. It does show that one operator/shift is a safe assumption for cost estimating purposes.

Usually, maintenance costs can be estimated at approximately 1% of the product manufacturing cost. Perhaps the reason for the low maintenance costs is due to the maximum corrosive conditions usually encountered, making it mandatory to give careful consideration to the selection of materials of construction.

R. M. Wheaton

A. H. Seamster

ROBERT M. WHEATON, a division leader with The Dow Chemical Co.'s physical research laboratory, joined the company in 1946.

All his experience at Dow has been with the physical research laboratory. He was a chemist for three years and initially was engaged in pilot-plant supervision (chlorostyrene). Later, he worked on the preparation of substituted styrenes. From 1949 to 1956, he served as a group leader, working on ion-exchange resins. He continued in this field following his advancement to division leader in 1956.

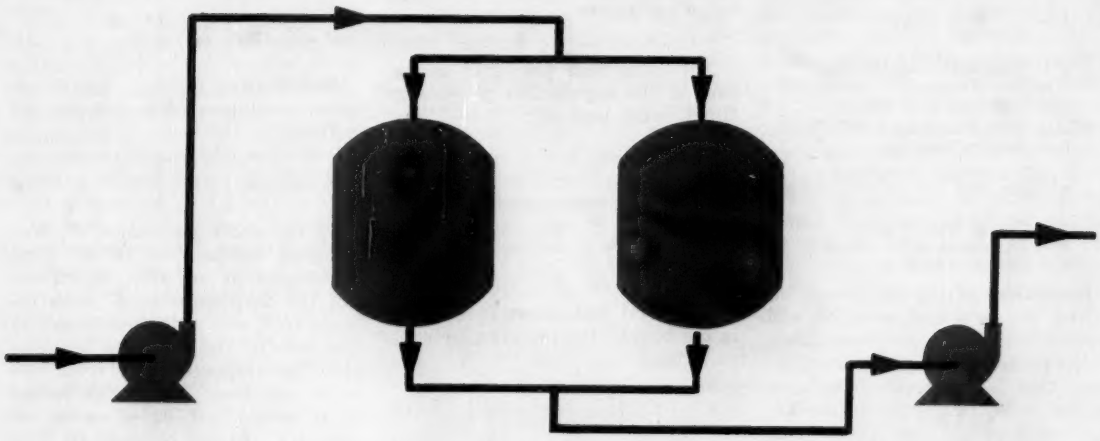
Wheaton has published 10 papers on ion-exchange resins and is named as inventor or co-inventor on ten patents.

Prior to joining Dow, he was with the Celotex Corp. and Trojan Powder Co. He is a member of ACS and RESA.

ALFRED H. SEAMSTER, a project leader in the engineering division of The Dow Chemical Co.'s physical research laboratory, joined Dow as a laboratory helper at Midland in 1940.

He was a laboratory assistant with Dow's Texas Div. at Freeport from 1943 to 1945. Following his graduation from Michigan State Univ. with a B. S. degree in chemical engineering in 1948, he returned to Dow, joining the main laboratory at Midland. He transferred to the physical research laboratory in 1950 and has continued there since. He was promoted to project leader in 1955.

Mr. Seamster is a member of AIChE.



Minimize Batch Equipment Cost

Mathematical method calculates optimum equipment size for batch processes by developing total cost equation for each process.

S. E. KETNER, American Cyanamid Co., New York.*

When designing a batch process, a designer must choose his equipment sizes to give minimum capital investment. This is an easy matter for a continuous process where equipment size depends upon the desired production rate. In a batch process, however, many combinations of equipment size will give the same amount of product. A typical example is a reactor with feed and discharge pumps. The production capacity depends not only on the reactor size but also on the pumping time required for feed and discharge. With very small pumps, a large reactor is required, and vice versa, for a given productive capacity.

With the cost equations derived in this article, the designer can calculate an estimate of the sizes for minimum investment. He should remember, however, that additional factors such as standard equipment sizes available, as well as safety and maintenance costs must still be considered in the final design.

We will assume the production capacity (W, gal./hr.) for a batch process to be fixed by market estimates. The problem, then, is to size the reaction and auxiliary equipment to minimize initial capital investment. If some pieces of equipment wear out faster than others, depreciation could be minimized instead, but we will consider only the first case. The time reactants are held at reaction temperatures, and other properties of the system must be known as well as the effect of equipment capacity on installed cost. The first step is to determine expressions for the installed cost of each piece of equipment in the process. We have developed several typical examples of this type of expression, as shown below and on the following page.

• Reactor or tank cost $= C_1V$ where

C_1 = Cost of reactor, \$/gal.
V = Vol. of reactants, gal./batch

• Pump cost $= \dfrac{C_2V}{t_2}$ where

C_2 = Cost of pump, \$/(gal./hr.)
t_2 = Pumping time, hr.

• Heat exchanger cost $= C_3A$ where

C_3 = Cost, \$/sq.ft. of area.

* At present with W. R. Grace & Co., Clarksville, Md.

A = Transfer area, sq.ft.

and, $A = \dfrac{QV}{U\,\Delta T_m t_3}$ where

Q = Total heat load, Btu./gal.
U = Heat transfer coefficient, Btu./(hr.)(sq.ft.)(°F.)
ΔT_m = Mean temperature diff., °F.
t_3 = Heat-up time, hr.

• Filter cost $= \dfrac{C_4 F V}{t_4}$ where

C_4 = Cost of filter, $/sq.ft.
F = Filter area, sq.ft./(gal./hr.)
t_4 = Filtration time, hr.

Regardless of the equipment involved, the total cost equation will involve items such as those above. If the process has a piece of equipment that is used more than once in the cycle, then appropriate adjustments in the reactant volume processed and definition of the time involved must be made.

The total cost equation will always contain volume of reactants per batch (V) as a common factor. There are two types of batch equipment—true batch items such as tanks; and intermittent-continuous equipment such as pumps. The intermittent-continuous type will always contain a time-of-use factor while the true batch type will not. For the general case:

Cost of true batch equipment $= C_j V$

Cost of intermittent-continuous batch equipment

$= C_i \alpha_i V / t_i$

The cycle time per batch is the sum of the appropriate processing times, taken here as:

$$\sum_1^m t_j + \sum_1^n t_i \qquad (1)$$

The production capacity W, gal./hr., is:

$$W = \frac{V}{\Sigma t_j - \Sigma t_i} \qquad (2)$$

The total equipment investment is the sum of the individual pieces, as follows:

$$I = V\Sigma C_j \Big]_1^m + V\Sigma(C_i\alpha_i/t_i) \Big]_1^n \qquad (3)$$

The investment per unit capacity y is:

$$y = I/W = [\Sigma C_j + \Sigma(C_i\alpha_i/t_i)] \times [\Sigma t_j + \Sigma t_i] \qquad (4)$$

To find the minimum investment per unit capacity with the corresponding cycle times, we take the partial derivatives of y with respect to the intermittent times and equate them to zero. The true batch equipment has a fixed time determined by reaction kinetics or other outside factors and the capacity is merely the reactant volume. The equations to be solved simultaneously, then, are:

$$\frac{\partial y}{\partial t_1} = \frac{\partial y}{\partial t_2} = \cdots \frac{\partial y}{dt_n} = 0$$

For the kth stage, processing time:

$$\frac{\partial y}{\partial t_k} = \left(\Sigma C_j + \Sigma \frac{C_i\alpha_i}{t_i}\right) - \frac{C_k\alpha_k}{t_k^2}(\Sigma t_j + \Sigma t_i) = 0 \qquad (5)$$

and:

$$\frac{C_k\alpha_k}{t_k^2} = \left(\Sigma C_j + \Sigma \frac{C_i\alpha_i}{t_i}\right) \Big/ (\Sigma t_j + \Sigma t_i) \qquad (6)$$

Since $C_k\ a_k/t_k^2$ is equal to the above summation for all i items, then:

$$C_1\alpha_1/t_1^2 = C_2\alpha_2/t_2^2 = \cdots C_n\alpha_n/t_n^2 \qquad (7)$$

therefore:

$$t_i = t_1\sqrt{C_i\alpha_i/C_1\alpha_1} \qquad (8)$$

and:

$$\Sigma t_i \Big]_1^n = \frac{t_1}{\sqrt{C_1\alpha_1}} \Sigma \sqrt{C_i\alpha_i} \Big]_1^n \qquad (9)$$

also, from Eq. (8):

$$\Sigma \frac{C_i\alpha_i}{t_i} \Big]_1^n = \frac{\sqrt{C_1\alpha_1}}{t_1} \Sigma \sqrt{C_i\alpha_i} \Big]_1^n \qquad (10)$$

Substituting Eq. (9) and (10) in (6) and solving for t_1 gives:

$$t_1^2 = C_1\alpha_1\Sigma t_j \Big]_1^m \Big/ \Sigma C_j \Big]_1^m \qquad (11)$$

Substituting Eq. (11) in (7) allows calculation of values for all t_i from:

$$t_i^2 = C_i\alpha_i\Sigma t_j \Big]_1^m \Big/ \Sigma C_j \Big]_1^m \qquad (12)$$

In the above derivation, C_i was assumed independent of t_i. This assumption is not true, of course, but the derivatives of C_i with respect to t_i are sufficiently small in the area of the optimum to allow close convergence in a trial and error solution. That is, an initial C_i is determined, based on an assumed t_i. A new estimate of t_i is calculated from Eq. (12) and the procedure repeated until t_i remains constant. This will be the operating time for the ith piece of equipment corresponding to a minimum investment per unit production rate. The number of iterations necessary to determine t_i depends, naturally, on how close the first guess is to the best time. About six iterations at the most are required, with three to four as an average.

Although equipment such as pumps is available only in certain sizes, this should be ignored until an optimum time cycle is determined. Then further calculations can be made considering available standard sizes in the range indicated by the optimum.

Nomenclature

A	Heat transfer area, sq. ft.
C_i	Cost of intermittent-continuous type equipment, $/capacity rate.
C_j	Cost of jth piece of true batch equipment, $/gal. of reactants.
F	Filter area required, sq. ft./(gal.) (hr. filtered).
I	Total equipment investment, $.
m	Number of true batch pieces.
n	Number of intermittent-continuous pieces.
Q	Total heat load, Btu./gal.
t_i	Time intermittent-continuous equipment is in use, hr.
t_j	Time batch equipment is in use, hr.
Δt_m	Mean temperature difference, °F.
U	Heat transfer coefficient, Btu./(hr.) (sq. ft.) (°F.).
V	Volume of reactants, gal./batch.
W	Production capacity, gal./hr.
y	Investment per unit capacity, $/(gal./hr.).
α_i	Conversion factor characteristic of processed material.
	Subscripts 1, 2, . . . 6 refer to individual pieces of equipment.

Plot Cost Data

It is important to have continuous curves of the cost data plotted in the proper units of installed cost per unit working capacity versus total capacity. For instance, where tanks and reactors are concerned, the costs should be in terms of volume of reactants so that average is a part of the cost figure.

In the general solution that we have worked out, the problems of multi-units and overlapping in the time cycle were not considered, for the sake of simplicity. It turns out, however, that in these cases the solution is of the same form as Eq. (12) and convergence is just as fast as in the general case. In a very complicated batch processing scheme, the derivations may have to be repeated to obtain the proper equations.

Examples Illustrate Method

The following three batch processes are outlined to illustrate the method. In all cases, the cost data are from Aires and Newton, "Chemical Engineering Cost Estimation," McGraw-Hill (1955). The data have been adjusted to be in terms of installed cost per unit operating capacity.

Example I—Consider a simple batch process with a pump feeding a pressure reactor from a large storage tank. After reaction is complete, pressure developed during the cycle blows the batch out of the reactor. Reaction and discharge require 1 hr. operating time. Sales estimates indicate a production capacity W of 1,750 gal./hr.

$$W = \frac{V}{t_1 - t_2} = 1{,}750$$

where:

t_1 = Pumping time, hr.
t_2 = Reaction and discharge time, hr. or, 1 hr.

The total installed equipment cost is:

$$I = \frac{C_1 V}{t_1} + C_2 V$$

where:

C_1 = Hourly pumping cost, \$/gal.
C_2 = Reactor cost, \$/gal.

The installed cost per unit capacity is:

$$y = \frac{I}{W} = \left(\frac{C_1}{t_1} + C_2\right)(t_1 + t_2).$$

From the general solution, Eq. 12, the optimum pumping time is: $t_1 = \sqrt{C_1\, t_2 / C_2}$

An initial estimate of the time cycle must be made to estimate C_1 and C_2. Assume a pumping time of 30 min. to make a batch cycle of 1.5 hr.

First Estimate: Values of C_1 and C_2 are taken from plots of cost per unit capacity versus capacity for the following batch volume:

$V = W\,(t_1 + t_2) = 1{,}750 \times 1.50 = 2{,}625$ gal.

C_2 is \$16.0/gal. and C_1 is \$0.154/(gal./hr.). The new estimate of pumping time is:

$t_1 = \sqrt{0.154 \times 1/16.0} = 0.098$ hr.

Second Estimate: With 0.098 hr. pumping time, the batch cycle time is 1.098 hr. The batch volume is now 1,922 gal. and the pumping rate is 17,860 gal./hr. From these data, C_1 and C_2 are 0.076 and 18.4 respectively. The second pumping time estimate is:

$t_1 = \sqrt{0.076 \times 1/18.4} = 0.064$ hr.

Third Estimate: Now the reactor volume is 1,862 gal. and the pumping rate is 29,094 gal./hr. The new C_1 and C_2 are 0.066 and 18.8, respectively. The pumping time now turns out to be 0.0592 hr.

Fourth Estimate: The reactor working volume is 1,853 gal. and the pumping rate is 31,400 gal./hr. The corresponding C_1 and C_2 are 0.0645 and 18.8, respectively. The new pumping time is 0.0588 hr.

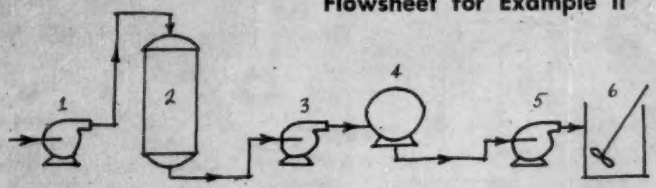
Final Estimate: With pumping time of 0.0588 hr. or 3.5 min., the batch volume is again 1,853 gal. C_1 and C_2 are the same as in the fourth estimate. The final process, then, would have a 1,853 gal. reactor and a 31,500 gal./hr. pump. The pumping time is 3.5 min. and the reaction time 1.0 hr. to give 1,750 gal./hr. production capacity. The difference in installed cost between the first and final estimate is about 14%. Table I shows this cost comparison.

The next step would be to find

First Example Estimate Comparison—Table I

	First Estimate	Final Estimate
Pumping time, hr.	0.500	0.0588
Reactor working volume, gal.	2,625	1,853
Pump cost, \$	809	2,032
Reactor cost, \$	42,000	34,836
Total installed cost, \$	42,809	36,868

Flowsheet for Example II



Second Example Estimate Comparison—Table II

Batch Cycle	First Estimate	Final Estimate (Optimum)
$t_1 + t_2 + t_3$, hr.	3.0	2.931
t_1, hr.	0.5	0.072
t_2, hr.	2.0	2.000
t_3	0.5	0.859
Reactor, gal.	1,500	1,466
Charging rate, gal./hr.	3,000	20,360
Filtering rate, gal./hr.	3,000	1,710
Production rate, gal./hr.	500	500
Installed Cost, \$		
Pump (1)	585	1,466
Reactor (2)	31,050	30,786
Pump (3)	585	495
Filter (4)	22,950	16,558
Pump (5)	585	495
Tank (6)	10,650	10,555
Total installed cost, \$	66,405	60,355

what equipment sizes are available in the vicinity of the calculated optimum, and then pick the combination giving the desired 1,750 gal./hr. at minimum investment.

With One Reactor

Example II—Here, six pieces of equipment are involved, as shown above. Material is pumped from a large, existing storage vessel by pump (1) to reactor (2). The reaction requires 2 hr. and the product goes out by pump (3) through a rotary drum filter (4) and is pumped (5) to a hold tank (6). The desired production rate W is 500 gal./hr. The time cycle is the sum of the charging time t_1, reaction time t_2, and filtering (discharging) time t_3. The reactor working volume is:

$$V = W(t_1 + t_2 + t_3)$$

and the installed cost in \$/(gal./hr.) capacity is:

$$y = \left(\frac{C_1}{t_1} + C_2 + \frac{C_3}{t_2} + \frac{C_4 F}{t_3} + \frac{C_5}{t_3} + C_6\right) \times \frac{}{(t_1 + t_2 + t_3)}$$

where: C_1, C_2 and C_3 are installed pump costs, \$/(gal./hr.) pumping rate; C_2 and C_6 are installed costs for the reactor and the agitated holding tank, \$/gal.; C_4 is filter cost, \$/sq. ft.; and F is filter area required, sq. ft./(gal./hr.). We will assume this last to be 0.05.

Rearranging the above equation with $C_3 = C_5$, we have:

$$y = \left[\frac{C_1}{t_1} + (C_2 + C_6) + \frac{2C_3 + C_4 F}{t_3}\right] \times \frac{}{[t_1 + t_2 + t_3]}$$

From Equation 12, the best pumping and filtering times are:

$$t_1 = \sqrt{\frac{C_1 t_2}{C_2 + C_6}}$$

$$t_3 = \sqrt{\frac{(2C_3 + C_4 F)t_2}{C_2 + C_6}}$$

Table II shows the initial and final calculated estimates of installed cost.

With Two Reactors

Example III—The rotary filter in Example II is the second most expensive piece of equipment. Two small reactors which would alternately feed the filtration unit would allow purchase of a smaller filter and possibly reduce the total investment. Also, the hold tank size could be cut in half. Consider, then, the system shown at left.

The initial time cycle is estimated so that the filtration unit will be in continuous operation—that is, $t_1 + t_2 = t_3$. In the following equations the supscripts are those of Example II. Remember, though, that the volume V is of one of the two reactors.

The time cycle is:

$$(t_1 + t_2 + t_3)/2$$

Reactor volume is:

$$V = W(t_1 + t_2 + t_3)/2$$

Cost/unit capacity is:

$$y = \left[\frac{C_1}{t_1} + (2C_2 + C_6) + \frac{2C_3 + C_4 F}{t_3}\right] \times \frac{}{[t_1 + t_2 + t_3]}$$

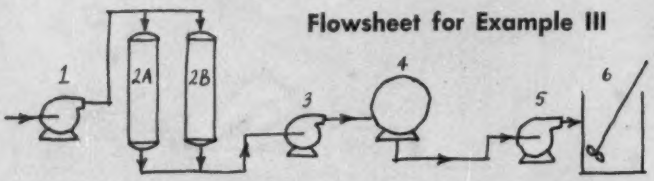
The optimum operating times are:

$$t_1 = \sqrt{\frac{C_1 t_2}{2C_2 + C_6}}$$

$$t_3 = \sqrt{\frac{(2C_3 + C_4 F)t_3}{2C_2 + C_6}}$$

Table III shows the initial and final design cycles calculated from these equations. It is evident that the single-reactor system of Example II is cheaper than the two-reactor system. It is also evident that sizing to allow continuous operation of the filtration unit is not economical.

Flowsheet for Example III



Third Example Estimate Comparison—Table III

Batch Cycle	First Estimate	Final Estimate (Optimum)
$t_1 + t_2 + t_3$, hr.	5.0	2.623
t_1, hr.	0.5	0.0474
t_2, hr.	2.0	2.0
t_3, hr.	2.5	0.576
Reactor, gal. (each)	1,250	656
Charging rate, gal./hr.	2,500	13,960
Filtering rate, gal./hr.	500	1,135
Production rate, gal./hr.	500	500
Installed Cost, \$		
Pump (1)	558	1,173
Reactor (2a)	28,375	20,992
Reactor (2b)	28,375	20,992
Pump (3)	346	443
Filter (4)	8,350	13,166
Pump (5)	346	443
Tank (6)	9,750	7,019
Total installed cost, \$	76,100	64,228

About the Author

S. E. KETNER graduated from Virginia Polytechnic Institute in 1950 with a B.S. in Chemical Engineering and obtain his M.S. in 1951 from the same school. From that time to 1956 he worked with the Virginia Smelting Co. on process improvement and new-product research. In 1956 he joined American Cyanamid Co. to work in production analysis, applying mathematics and statistics to process improvement. This year, Ketner joined W. R. Grace & Co. He is a licensed P.E. and a member of ACS, AIChE and the American Society for Quality Control.

Where Estimators Go Wrong

- **How accurate is analysis of cost data for the required estimate?**
- **Do labor, material and service costs include all factors that may be present in a given locality?**
- **What is the useful life of a currently prepared estimate?**

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Many important decisions rest on estimates which depend for their accuracy on the skills of the estimotor. This leads to the question: How well-equipped is the estimator to give an accurate answer?

In many cases, the estimator is a qualified engineer with several years of engineering and economic experience in his field. Therefore, he will be versed in its language and background and will be aware of what is demanded in constructing the project under consideration. His greatest difficulty will be in learning that, while physical laws are invariable, economic laws are based on human decisions that produce a continual change, outmoding cost data even as they are gathered.

It is the obligation of the cost engineer to supply management with cost estimates containing a minimum of inaccuracy at any point in the development of a project. Likewise, it is a vital necessity for management to provide the cost engineer with all the means needed to prepare a reasonably accurate cost estimate.

Upon a request for a cost determination, a feasibility investigation is undertaken to justify further study. Total costs of previous similar projects plotted against their total capacity, volume or area produce order of magnitude graphs that are adequate for such an approximate total cost. The cost engineer should know the controlling factors that determine his data, such as labor rates, productivity and location. If he does not know these, he does not know his margin of inaccuracy and hence will have a cost estimate of little value.

With the site selected and location plans showing sufficient data to estimate component parts individually, the degree of accuracy of a preliminary estimate depends on knowing the origin of the cost data. Indiscriminate use of graphs, indexes and average bid prices at this stage leads to wide discrepancies later between budget allowances and final costs.

It is usually easier for the cost engineer to set up graphs and tables based on his own experience than to torture general data into fitting his needs through a multitude of conversion factors and end with costs of unknown accuracy. Such general data are valuable for comparison purposes but not for particular cost estimates.

Use of average bid prices rather than average estimated prices again introduces inaccuracies of unknown amount because of unbalanced bidding. Such bidding is due to many causes. Items constructed first may be bid higher than final items to meet early payrolls. Some items may be left blank temporarily to absorb other last minute quotation variations or to meet competition as it develops near bidding time. Courtesy bids, which are usually high in case of actual award, provide for extra equipment and personnel if needed. Unless average bid prices are culled of such unbalance, they are useless even for comparative purposes.

Either simple or elaborate use of average bid prices for a definitive estimate is not only inaccurate but absurd because it puts the cost engineer in the position of going to the bidders for data to check the accuracy of their bids. If past bids were correct to use as a criterion, then present bids from the same contractors should be accepted at face value.

Determine Project Details

For the definitive estimate, accurate research and design demand accurate cost estimating. It is presumed that the design division or a consultant has prepared plans and specifications defining the scope of the work within the project limits. A meeting of minds at this point between designer and cost engineer will eliminate many inaccuracies later at the contract stage. It is much easier to revise a project on paper rather than at the construction stage. Projects that are contracted before adequate plans, specifications and a cost estimate are available are in for a seige of inaccuracies.

While the plans determine the required dimensions, the plan notes and specifications determine the quality and hence the ultimate cost of the project. Ambiguous or generalized specifications are more likely to guarantee higher bid prices than quality construction. The general form of specification might cover the description of the payment item, construction methods

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required, method of measurement and basis of payment.

Accuracy demands that a project be broken down into its simplest recurring parts or payment items based on units such as cu. yd., sq. ft., lb. or lineal ft. After such analysis, the time required to prepare a definitive estimate may be reduced by the synthesis of related components to approach the time required for a factored order-of-magnitude estimate.

Include All Cost Items

The definitive estimate is based on labor, material and service costs, the latter consisting of any costs not directly chargeable to labor or material. This cost could be considered as the service charge for a contractor supplying labor and equipment to put specified material in place. Whether the material is ore in the ground or the most refined product, the labor-material-service relationship will hold, varying percentage-wise with the project. It is assumed that most projects will be constructed by general contractors as their experience, ready equipment and trained crews more than offset their contracting service charge.

When the project is constructed by contract, there are then only two points of contact with the capital structure which are the engineering-contingency fund and contract payments. The engineering cost will be the entire cost of preparing the plans, specifications and estimate plus construction supervision and whatever administrative costs are considered chargeable to the project. The contingency allowance is set up to cover the cost of almost inevitable oversights and unforeseen additional work.

The engineering-contingency fund can be set up as a percentage of the total contract cost both for simplicity and as an incentive to the engineering staff. The greater the accuracy of the plans, specifications and estimate, the less need for change orders after construction starts.

The general and project overhead will be that of the contractor, charged off in contract payments. The general overhead consists of office personnel and expense, performance bond, insurance and taxes, while project overhead consists of supervisory personnel, equipment, fuel, safety measures, local office expense and contractor's service charge. When construction is complete and the project taken over for operation and maintenance, the corporate overhead is then charged to the project.

In any recurring project type, the service cost will usually bear a constant ratio to the total labor cost. This service factor can then be combined with a similar labor factor so that the labor-service cost of any payment item can be obtained in one operation. There remains only the material cost to be added to obtain the total unit cost of the item.

Establish Labor Costs

Labor costs are based on productivity, shown on previous field reports, and current wage rates. Productivity will vary with season, location and economic conditions. Location variations may necessitate duplicate manhour lists. An average wage rate for all labor working on a project can be determined. As these rates usually vary at the same time, it is safe to equate the average rate to one trade only to obtain a labor factor. By multiplying the total manhours required by the common labor rate times the labor factor, the total labor cost can be obtained in one operation.

This labor factor can also be combined with the service factor above to get the total labor-service cost in one operation. This method prorates all service costs equitably over all payment items rather than concentrating these costs over a few payment items.

How to Find Material Prices

Material quotations for the larger items should be obtained for each project. At least two and preferably three suppliers should be asked to quote. The miscellaneous items need be checked only at infrequent intervals. Oral quotations lack the considered judgment of written ones which are preferable but which still must be weighed by the cost engineer as to their real value.

A salesman pushing a particular material may quote an unrealistically low price to the design division to make his product more acceptable but this should be disregarded if relayed to the cost engineer. A direct request to the supplier for a quotation may bring a list price that is too high to use. If the material in question is competitive, the quotation will be lower. This figure will probably be the best one to use, as the difference between this quotation and the one the contractor can expect will furnish an estimating contingency sufficient to cover such things as unexpected labor rate increases or transportation difficulties.

If the bidder must bid under the cost engineer's estimate to obtain a contract, the supplier will shade the quotation a bit lower to such a bidder. If the bidder is awarded the contract and there is good competition among the suppliers, he can expect a still lower figure at the time he places his order. Even this figure may vary between small and large volume purchasers. Material prices are usually the hardest of the three price components to establish.

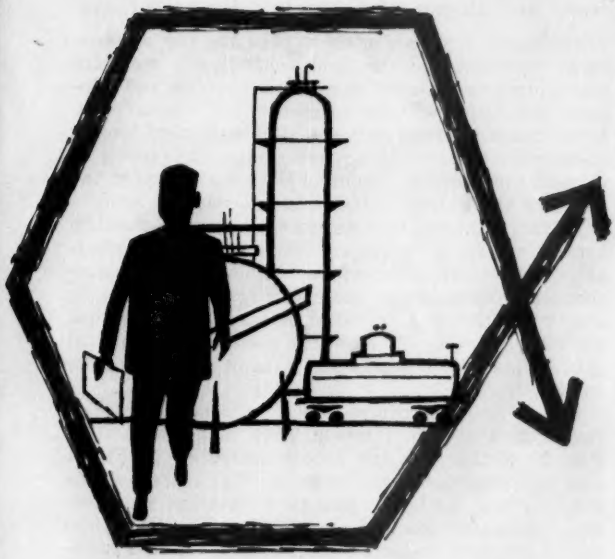
After the plans and specifications are approved and such additional costs as utilities and storage have been worked out, the detailed estimate can be completed. This estimate should normally be within 5% of the lowest firm bid. The low bid will supplant this estimate when the contract is signed. If the low bid is considerably less than the estimate and the other bids, it may not be the bargain that it seems.

Contractors are usually rushed in their estimating and have been known to overlook as much as a third of the work called for in the plans. Some contractors are "hunch" bidders who first set a total price and work back to a detailed estimate. It is better to release a bidder from such a bid than to fight for quality work throughout construction.

The life of an estimate in today's market is probably no longer than six months. Forecasting beyond that point or resting decisions on an unrevised estimate of greater age is risky. It is in this area of forecasting that generalized graphs and indexes in the literature are most helpful.

These historical graphs could show a truer picture if they were based on an identical dollar value throughout. The usual graph is a quantitative one, showing the number but not the value of the dollars involved. The relative quality of the work covered in the graphs might also tend to level them out if it could be included.

However, no amount of accuracy on the part of the cost engineer can precisely chart this graph.



Systems Engineering, Part 8

Control Theory

Control systems design requires a knowledge of system response, use of some unfamiliar tools and techniques.

THEODORE J. WILLIAMS, Monsanto Chemical Co., St. Louis, Mo.

To specify process controls, the systems engineer must

1. Note independent process variables and determine which may be subject to upsets affecting processing.
2. Specify which independent variables should be separately controlled and which should be controlled by feedback from process-dependent variables. Determine best methods and locations for sampling required independent and dependent variables.
3. Specify required control modes and their settings to give optimum response of the process output to upsets of each controlled variable.
4. Coordinate his work at design stage, where possible, so that process performance will benefit from plant dynamics and so that the control problem can be simplified as much as possible.

We've already discussed how items 1, 2 and 4 fit into systems engineering. It is item 3 which shall concern us in this and the next part of this series.* We will address the question, "How do you specify required control modes and determine optimum response for a particular process and its associated control system?"

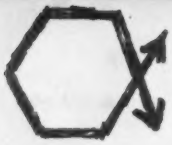
First, we must obtain a mathematical model of the system as described in Part 4 of this series. This model must include descriptions of the proposed control scheme and of the process. Once the complete mathematical model has been obtained we can carry out a control study. An immediate objective is to obtain a solution for the set of differential equations which comprises the model. From this solution, applicability of the proposed control scheme will be evident.

Linear and Nonlinear Systems

Basic automatic control system theory (servomechanism theory) and, therefore, process control theory are based upon the study of linear systems. Linear systems are those whose dependent variables exhibit the following characteristics:

1. All dependent variables give a continuous response over the complete range of values.
2. All coefficients of the differential equations of the system are either constants or functions of time only.
3. If several forcing functions (driving forces) are applied at the same or different locations in the system at the same or a different time, the total response produced is the same as the sum of the response to the individual functions considered separately. (This is the principle of superposition.)
4. Magnitude of the response of a linear system is directly proportional to magnitude of the input function. This permits magnitude of the response to be normalized into the form of the magnitude ratio, mak-

* Based on the 1959 Schoch Lecture at the University of Texas, the series has appeared in *Chemical Engineering*, Feb. 8, 1960, pp. 121-6; Mar. 7, pp. 131-6; Apr. 4, pp. 139-44; May 2, pp. 121-6; May 30, pp. 97-102; June 27, pp. 113-118; July 25, pp. 119-124.



Tools of the Control Engineer

For systems that can be considered linear:

Low to moderate complexity

- Analytical solutions of the differential equations of the system by (a) classical methods and (b) established short-cut methods such as rules of Ziegler and Nichols.[1,2]
- Graphical solutions by (a) frequency-response methods—Bode[2,3,4] and Nyquist[3,4] and (b) transient-response methods—root-locus.[5]
- Analog computer simulation, usually with transient response.

High complexity

- Only computer solution is satisfactory for complex systems because of labor involved in analytical or graphical techniques.

For systems treated as nonlinear:

Low complexity

- Analytical solutions.
- Graphical solutions—phase plane analysis.[6,7]
- Analog computer simulations.

Moderate to high complexity

- Only computer solution can give satisfactory answers for a reasonable expenditure of effort.

ing useful such graphical presentations as the Bode and Nyquist diagrams which will be described below.

Nonlinear systems do not follow one, several or possibly all of these rules. For example, magnitude of the response of a nonlinear system is usually a function of its input magnitude. The Bode diagram of a typical linear system follows a single curve regardless of input magnitude, but response of a nonlinear second-order system may include any of many possible responses as input magnitude is varied. Too, natural response frequency of a nonlinear system may vary with its magnitude, but response of a linear system, if oscillatory, is at constant frequency for all time.

As a result, the theory of nonlinear systems has been almost completely developed around discussions of their *transient* response and that of linear systems has centered on *frequency* response considerations. These two special responses will be examined here.

Let's first confine ourselves to the theories and methods of linear systems. Classical methods of solution are those covered in basic text books on ordinary differential equations. Short-cut methods, such as those of Ziegler and Nichols, that are so important for adjustment of controllers already installed have only a limited value in design. They will, therefore, not be discussed further here. We call your attention, though, to the book by Tucker and Wills[3] which gives a truly excellent discussion of these techniques and is highly recommended for the chemical engineer who's interested.

Shown in the table are several methods to evaluate the mathematical equations representing a physical system. With these we can determine theoretically the responses and characteristics of the system in which we are interested.

Study and Design of Controls

Automatic process control implies the use of feedback: the control instrument continuously monitors some output variable of the controlled process and compares this output with the desired value of the variable. Error resulting from this comparison is used by the instrument to compute a correction to the setting of the valve or other final control element, returning the value of the output variable to the desired level.

To carry out the best design of a servomechanism control system we must understand operating characteristics (responses) of each element of the control loop, for example, those of Fig. 1. We must be able to write the differential or algebraic equations of each particular element or to produce an empirical expression from experimental data to accomplish the same purpose.

Simplifying, the control engineer usually lumps all the devices of Fig. 1 into a block diagram such as Fig. 2. Notice that the actual controller of Fig. 1 and the theoretical controller of Fig. 2 are not the same device. As here, often the correction computer and associated control lines form the theoretical controller and the error detector is carried separately.

Of the possible responses of a system to various inputs or upsets, usually study is confined to two special types of response—transient response and frequency response.[11] Transient response is generally used in solving the differential equations of the system analytically or by electronic computer. Frequency response is especially valuable for those systems which can be described by linear ordinary differential equations.

Transient Response of Systems

Transient response is response to a step function, or other change in operating point, applied as a forcing function to the system. When subjected to such a forcing function, practically all chemical processes are monotonic in response when operating without control[8]; they are either completely stable to the point of being overdamped (Fig. 3a), or they are only conditionally stable and deviate continuously once disturbed (Fig. 3b) until some other limiting factor has been encountered.

By far the majority of systems are characterized by Fig. 3a. Chemical reactors with incorrect heat generation-heat removal characteristics are the major group to follow Fig. 3b, as we saw in Part 6 of this series. However, once automatic control is applied, chemical systems are no longer necessarily monotonic. Depending on characteristics of the system being forced, five different types of curves may finally be obtained. Shown in Fig. 4, these responses are called (a) stable and overdamped, (b) stable and critically damped, (c) stable and underdamped, (d) oscillatory or on the threshold of stability and (e) unstable.[11]

We have already seen the overdamped case in Fig. 3a. A physical example of the underdamped type of curve is best seen in the action of a spring subjected to a displacement and then released. Assuming smaller and smaller spring friction, the degree of oscillation increases until for the case of the perfect

Flowsheet Becomes Block Diagram

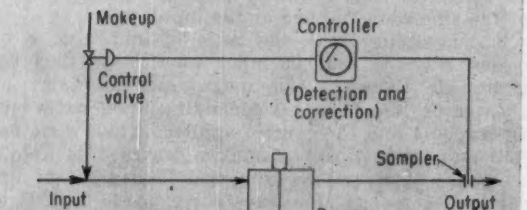


Fig. 1

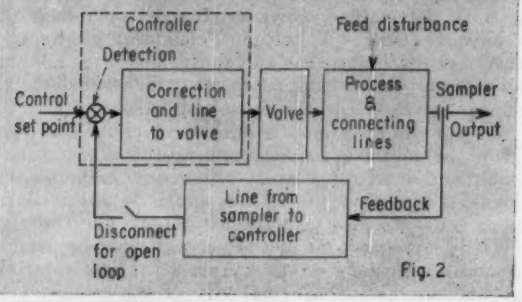


Fig. 2

spring (no internal friction) the threshold stability condition, a permanently oscillatory system, is obtained.

The unstable condition is not normally present in purely physical, passive systems but can easily be present in those involving exorthermic chemical reactions. Instability requires activity of some sort and an internal source of energy to support the growing transient response.

Whenever a feedback loop and an automatic controller are added to a physical system, i.e., whenever a closed-loop system is formed, an oscillatory or unstable system is an ever-present danger. Too large a controller constant (i.e., gain) results in a correction whose effect is larger than that of the original disturbance. Usually the effect of this larger correction is then amplified by subsequent corrections so that variations of the output variable quickly get out of hand.

For a linear system, size of the input step function has no bearing on stability of the system. For nonlinear systems, however, size of the step may be a very important factor in stability.

Graphs of Fig. 4 can be obtained experimentally. But they are usually obtained from the general differential equation of the system as the particular solution with a step forcing function. By the nature of mathematical representation of the step function, general equations of the system must usually be solved by the Laplace transform or by a similar operational calculus method when hand computation is to be used.[12, 13]

Equations for processes fitted with a feedback loop, however, and particularly those fitted with control equipment, can be solved by this method only up to a relatively low degree of complexity. Beyond this, methods of the Laplace transform break down from sheer size of the algebraic manipulations involved, and an electronic computer is necessary.

For an involved piece of equipment whose differential equations are too complex for computer solution or whose time constants are unknown, system response to the step input often must be obtained experimentally. The step input can be simulated readily in the physical system by a rapidly opened valve, an on-off switch or a sudden change in set point of a controller. However, this is the most severe upset to which a system can be exposed; damage to the system is quite possible if improperly used. Such a response is almost always obtained in a closed-loop as in Fig. 2.

The critically damped system is, of course, the most desirable for the control engineer to obtain. Rather than chancing an overdamped system with the resulting system sluggishness, however, he usually attempts to achieve a slightly underdamped response. Many criteria have been established to pick this best response.[5, 13] These will not be discussed fully here, but one common criterion is that detailed in Fig. 4c. Here the first overshoot must be equal to or less than 20% of the input disturbance, and each successive oscillation must fit within an envelope defined by $\pm a/et$. Other criteria are discussed in Refs. 5 and 13.

Frequency Response of Systems

Application of a sinusoidal function disturbance rather than a step function to the input variable is the other method commonly used in determining process-controller system response and stability. The graph of magnitude *vs.* time of the output variable is then compared to a similar graph of the disturbance applied to the input variable. From this we can

Uncontrolled Response to Step Function

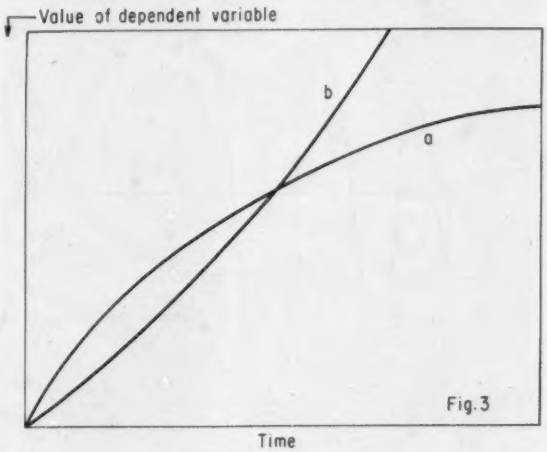


Fig. 3

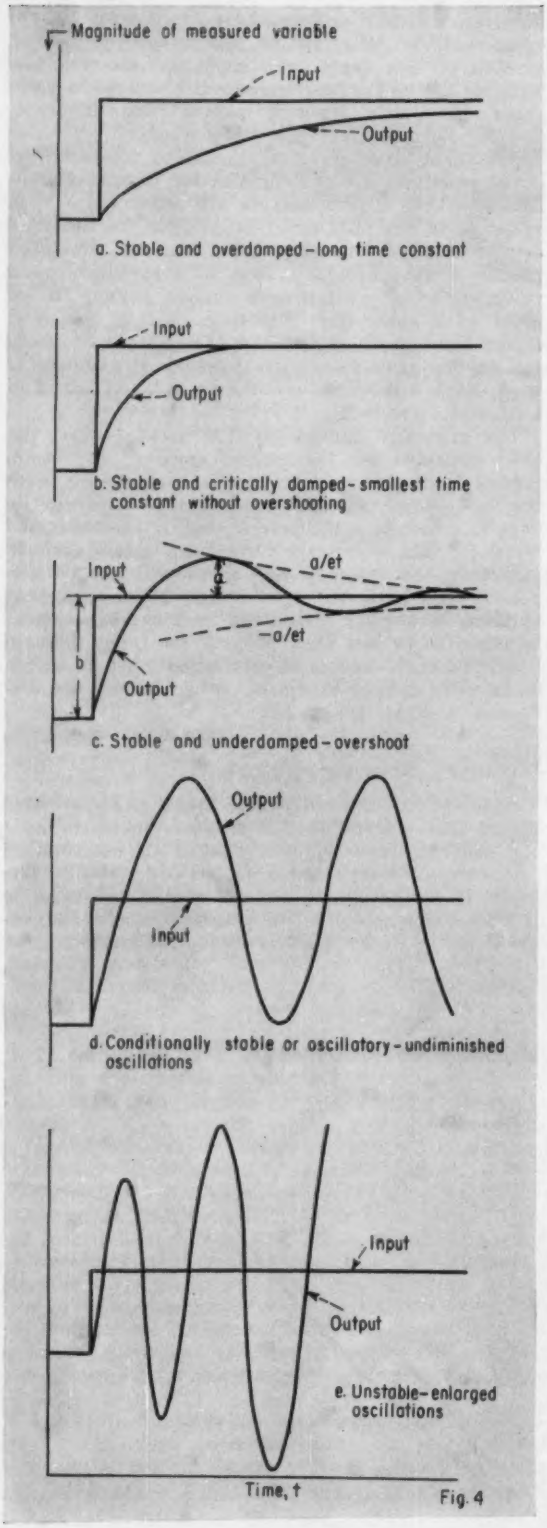


Fig. 4

determine (a) magnitude of the output peaks as compared to the input and (b) time differential between corresponding points on the two curves as compared to time required for one complete cycle of the sine wave applied at the input.

A magnitude ratio—the ratio of amplitude a of output wave to that of input wave b—is thus determined. Value of this magnitude ratio may be greater or less than 1.0 depending upon nature of the process and the control applied. Time variation between common points on two waves δ is known as phase shift and is expressed in degrees of arc (time of complete sine wave corresponds to 360° of arc). Fig. 5 diagrams these concepts.

Magnitude ratio and phase shift of the output variable are definite functions of frequency of the applied sine wave; they must be determined for a wide range of frequencies to be valuable. They need only be determined, however, for the open-loop (no feedback) case, i.e., without considering effect of feedback on the process and controller. Fig. 2, which shows the closed-loop case used for transient response, also details the open-loop case.

Use of the open loop is possible because there are graphical methods for determining the effect of feedback and controller upon frequency response. In transient response, equations must be resolved for each separate case to be investigated. The complete closed-loop equations of the process must be used as general equations of the process. Their solutions greatly increase the complexity of the mathematics involved.

Three Graphical Design Techniques

Nyquist[14] and Bode[13, 15] methods are most commonly used to plot open-loop frequency response data. With them we can determine the proper controller to use on a process and check response and stability of the resulting process-controller complex.

The Nyquist, or polar, diagram is the locus resulting from plotting the magnitude ratios obtained for each of a complete spectrum of applied frequencies *vs.* the corresponding phase shifts obtained for each of the same frequencies.

Fig. 6 shows two such frequency-response curves, each plotted for three values of the applied frequency ω, where $\omega_2 > \omega_1 > \omega$. Phase shift δ is plotted clockwise, and at each frequency the magnitude ratio M is measured along the radius. Fig. 6 shows the point $M = -1$, $\delta = 180°$; the criterion for stability is that when proceeding along the curve in the direction of increasing frequency, this point must lie to the left of the curve. Curve A of Fig. 6 represents an unstable system, curve B a stable system.

The Bode, or log-modulus, plot actually consists of two graphs: logarithm of the magnitude ratio on the ordinate *vs.* logarithm of the applied frequency on the abscissa and phase shift in degrees *vs.* logarithm of the applied frequency. To ease comparison these graphs are usually plotted on the same sheet of paper with a common abscissa as shown in Fig. 7. Stability criterion is that the magnitude ratio curve must cross the zero line at a lower frequency than the phase-shift curve crosses the −180° line.

In addition to Nyquist and Bode plots, used almost exclusively for frequency-response studies, there is

Basis for Frequency Response

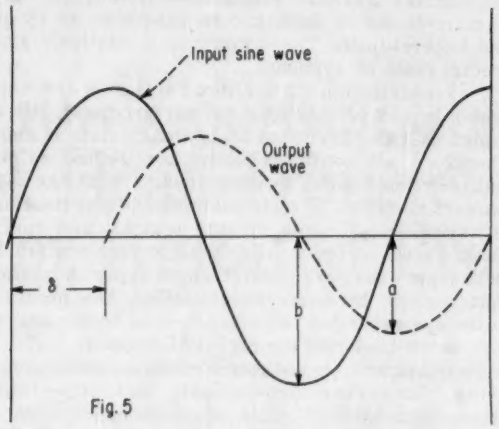


Fig. 5

a third plotting method applicable in both transient- and frequency-response studies—the Evans root-locus method.[26, 27]

Here, as diagrammed in Fig. 8, roots of the characteristic equation of the open-loop system are plotted on a complex plane. For any such set of roots, there is a curve or locus on the diagram which defines all possible roots of the corresponding closed-loop equation.

Each of the points plotted on Nyquist and Bode graphs is also a point on the new locus, and this helps greatly in establishing the locus on the root-locus diagram. Stability determinations can be made as shown in Fig. 8. Graphic techniques allow the closed-loop transient response and the frequency response to be determined directly from this diagram. These are described thoroughly in Refs. 16 and 17. Although relatively new, the root-locus method has found wide acceptance.[5]

Graphs Shorten Work, Increase Insight

In each of the three graphs—Nyquist, Bode and Evans—frequency-response results can be plotted directly from the differential equation itself without going through the complete solution required for transient response. The same form of a linear differential equation always gives a graph of the same appearance regardless of the system whose equation is being graphed.

An added factor in favor of these three plotting methods is the principle of superposition. This principle, a property of linear systems, states that response of a complex system is a product of responses of those simpler elements considered to make up the complex system.

As long as superposition can be considered as holding, i.e., as long as the assumption of a linear system is valid, responses of complex systems are relatively easily obtained. Responsible for the popularity of frequency-response methods in aircraft and

Graphical Design Techniques

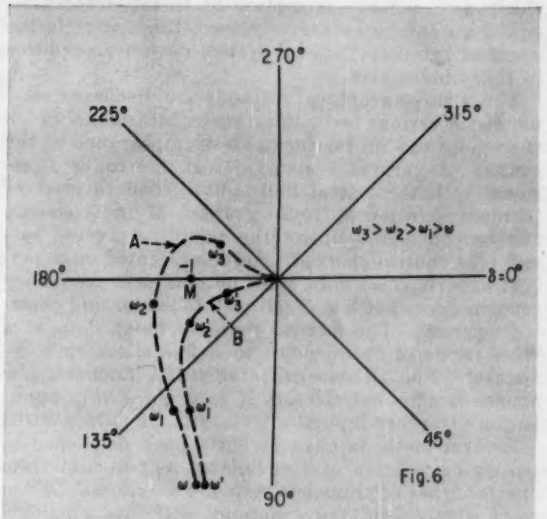


Fig. 6

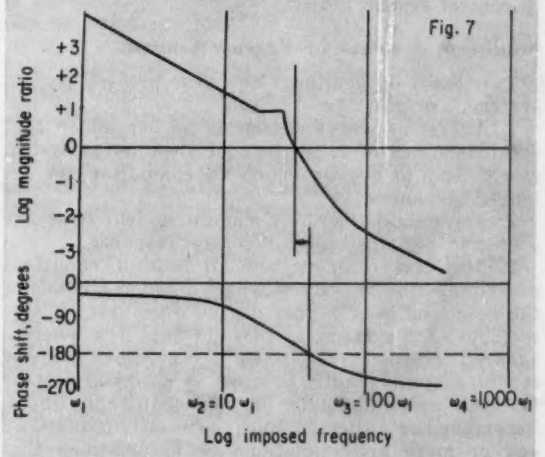


Fig. 7

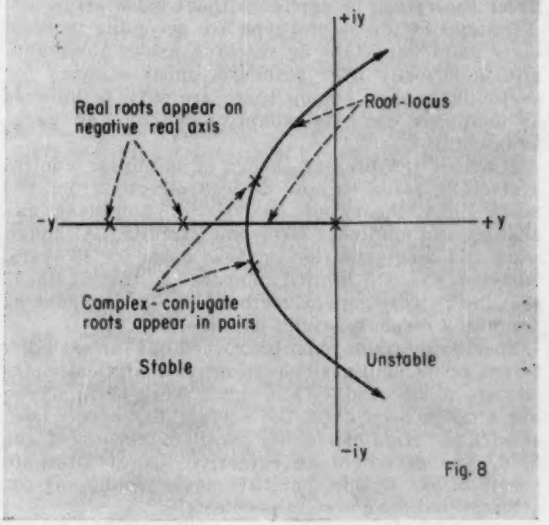


Fig. 8

electronics, where assumption of linear differential equations can be extensively used, this factor is the heart of extensive control system design procedures in those industries.

These three graphical methods are discussed completely in various texts on servomechanisms to which the reader can go for examples of appearance of the graphs of various systems. Most controller functions, both theoretical and actual, lend themselves to representation on these graphs. If the elements can be considered linear, the complete process system plus control elements can be evaluated on paper.

If experimental data must be obtained, frequency response does not lend itself well to evaluating chemical systems. The method requires much data at a wide range of frequencies to define a system's response.[13] For an experimental study, transient response is more satisfactory if care is taken in application of severe inputs.

Several methods have recently been developed to permit calculation of frequency-response data from special types of transient-response solutions.[18] When more widely used, these methods will offer great aid to control system design.

Nonlinear Systems in Process Control

Two cases of nonlinear chemical process control systems are possible:

1. A system whose action is so nonlinear that approximations of it as the equivalent linear system would lead to drastic errors in computing the required responses.

2. A system deliberately made nonlinear to secure a specific, perhaps superior, control response.

In the first category are all sets of equations describing kinetic systems where order of any one of the reactions is of higher degree than first. It also includes such systems as those in fluid flow where a squared term is involved. Many other such systems can be brought readily to mind—a chemical process is much more likely to be nonlinear than linear. Reference to a system as linear is usually founded on one or more approximations or assumptions that linear theory can be applied without much error.

Systems of the second type are becoming increasingly more important as research shows their definite superiority over standard linear systems for particular tasks. Among these are such techniques as nonlinear damping, adaptive control and bang-bang control.

Much of the present theory of nonlinear control systems is based on, and derived directly from, the much older theory of analysis of nonlinear mechanics and nonlinear electronic circuits.[7] Although work has been extensive in these fields for 40 years, knowledge is still limited compared to that of linear systems because general methods of solution, such as frequency response, aren't possible.

Specific solutions must be worked out for each different set of nonlinear equations if analytical methods are to be used. While much work of this type has already been done, the surface has barely been scratched. Higgins, in his excellent review of the field,[7] has presented an extensive list of alternate possibilities. Briefly, here are some techniques for solving nonlinear system problems.

- Direct analytic solutions—solution in closed form in terms of such known functions as elliptic and hyperelliptic. These apply to a relatively small special class of systems.
- Linearization of nonlinear terms in the equations. In the *method of small perturbations*, it's assumed that the deviation from steady state is small. Therefore, all nonlinear terms are treated as constants or considered to vary linearly with the independent variable. In *sectional linearizations* the range of variation is broken up into regions, and special linear forms of the nonlinear terms are written for each region that are considered to apply throughout that region. In *series linearizations*, the nonlinear terms are expanded in various series forms and the first terms used over the region of interest.
- Graphical procedures include construction of phase plane (two dimensional) and phase space (three dimensional) plots of nonlinear system response. Almost impossibly difficult for anything more complex than a third-order system, the procedures are the isocline method, Lienard's method and arc-segment methods.[7, 9]
- Analog computer solutions.
- Numerical methods of solution, particularly on digital computers.

Of all those mentioned, we particularly recommend the analog computer. It is capable of simulating nearly all the types of functions normally considered in nonlinear control systems. Too, its graphical presentation of results is especially suited for the phase-plane plots usually used to represent nonlinear system responses.

As with linear systems, solutions of sets of nonlinear equations are necessary to find out the facts concerning stability and response data about the device under study. The same facts as for linear systems, with addition of influence of magnitude on stability, are needed for the nonlinear.

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Film Coefficients of Heat Transfer For Agitated Process Vessels

The author examines all published correlations on heat transfer film coefficients in agitated systems, adds data of his own and comes up with recommendations of the best to use in any specific case.

EDWARD J. ACKLEY, The Pfaudler Co., Div. of Pfaudler Permutit Inc., Rochester, N. Y.

DURING the past 15 years, there has been considerable investigation of heat transfer film coefficients for the agitated side of jacketed or coil-in-tank vessels. Most investigators agree on the general form of the equation for calculating the film coefficients, but certain variations do exist.

There is usual agreement on the use of dimensionless numbers. Correlation is ordinarily based on the method of correlation for conduits and plane surfaces proposed by Colburn and modified by Seider and Tate.[10] The only major difference between correlation for the general equation and for conduits and planes comes about because the Reynolds number for agitators must be used and this does not give a true picture of the flow of liquid in an agitated vessel.

Purpose of the present article is to summarize the investigations made in the past, attempting to show how the various studies differed, for example, in design of vessel, method of accumulating data, or the formulation of the equations. Supplementary data and recommendations which result from testing at The Pfaudler Co. are also included.

The discussion is divided into four major sections, each of which corresponds to one of the major types of agitator in general use today, that is, Paddles, Anchors, Propellers and Turbines. The main sections are subdivided into separate sections for each investigator who studied these agitators. There are other types of agitators in use at present, but there is little or no literature in existence so far to describe their influence on film coefficients.

PADDLES

Chilton, Drew and Jebens—The first significant study of film coefficients in agitated vessels was conducted by Chilton, Drew and Jebens,[5] using flat paddle agitators in both jacketed vessels and vessels with helical coils. A jacketed 1-ft.-diameter, dish-bottom vessel constructed of 12-in. and 14-in. Schedule 40 steel pipe was used. The coil was of ½-in. O.D. copper tubing, wound 7.7 turns on a 0.8-ft. mean diameter inside the vessel. Over-all height of the coil was 5.75 in. and the outside area was 2.42 sq. ft. The coil was placed in the vessel so that its lower edge corresponded to the lower edge of the straight side of the vessel. The paddle used was constructed of 14-ga. metal and was 0.6 ft. in length and 0.1 ft. wide. It was placed 0.15 ft. from the bottom of the vessel, level with the bottom of the coil.

Eight thermocouples measured the temperatures. Of these eight, three measured coil-wall temperature, one measured jacket-wall temperature and four measured the temperature of the agitated medium. The jacket-wall thermocouple was imbedded in a sidewall hole approximately 3/32 in. in diameter by ¼ in. deep. Copper-coil thermocouples were soldered into grooves cut approximately 3/32 in. deep. No baffles were used in any tests.

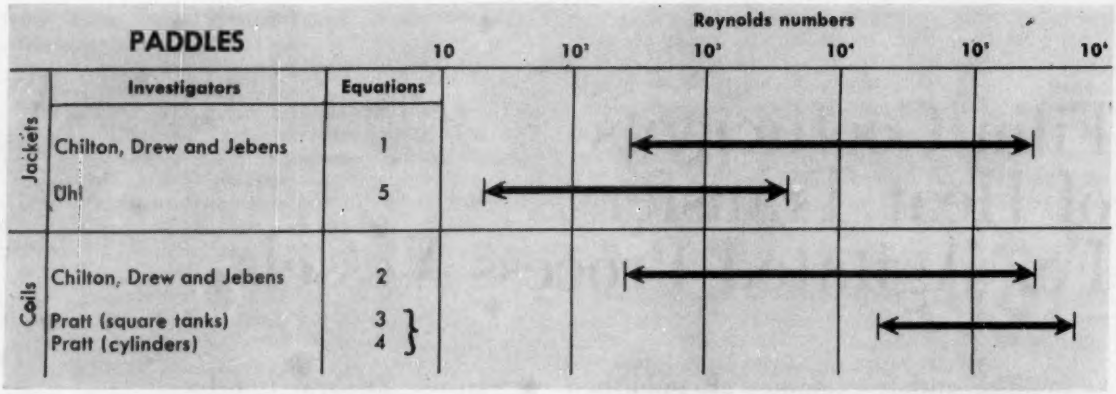
Tests were run under both steady and batch conditions. Results generally agreed, although the results from the batch tests did not have the consistency found in the steady-state tests because of the rapid change in temperature of liquids in the vessel.

In addition to the tests performed in the vessel just described, batch tests were conducted in a 5-ft. diameter geometrically similar vessel. Here again, batch-test results were not as consistent as those found in steady-state tests.

The Reynolds number range of the tests was 286 to 258,000.

The results of this investigation indicated the following correlation when a jacket was used. (In these and later equations, see Table I for significance of the dimensionless groups):

$$\frac{h_j D}{k} = 0.36(\mathrm{Re})^{0.67}(\mathrm{Pr})^{0.33}(\mathrm{Vis})^{0.14} \qquad (1)$$



When the coil was used the following equation resulted:

$$\frac{h_c D}{k} = 0.87(\mathrm{Re})^{0.62}(\mathrm{Pr})^{0.33}(\mathrm{Vis})^{0.14} \qquad (2)$$

Note that, in the coil equation, the authors still continued to use the vessel diameter as the correlating parameter. In the section on Turbines it will be noted that coil diameter is used as the correlating parameter. The use of coil diameter seems reasonable since the heat transfer coefficient designated in the Nusselt number is at the coil surface rather than at the vessel wall.

Pratt—Pratt[8] investigated the use of paddles of varying shape and number in both rectangular and cylindrical tanks. He used coils as the heat transfer barrier. Of his five vessels, three were rectangular and two cylindrical, and each vessel was fitted with a coil. It is assumed that the vessels were flat bottomed. The tests involved 25 different setups, using paddles in various combinations and sizes. Ten tests were performed using single flat blades, seven tests used two paddles, seven used three paddles, and one test used five paddles fixed to the agitator shaft.

Pratt recorded cooling water temperature on thermometers at the inlet and outlet of the cooling coil, while tank thermometers placed directly in the circulating liquid at levels corresponding to the top and bottom of the coil recorded liquid temperature.

There were no baffles and no attempt was made to measure coil-wall temperature. Over-all coefficients were calculated from the test data and pipe film coefficients obtained, using equations from the literature. With this information, Pratt obtained film coefficients for the agitated condition.

Pratt's results are shown in the equations:

For coils in square tanks:

$$\frac{h_c d_v}{k} = 39(\mathrm{Re})^{0.5}(\mathrm{Pr})^{0.3}(d_v/d_p)^{0.5}(W/d_v)^{0.35}(L^2 l_v/d_t^3)^{0.1} \qquad (3)$$

For coils in cylindrical tanks:

$$\frac{h_c D}{k} = 34(\mathrm{Re})^{0.5}(\mathrm{Pr})^{0.3}(d_v/d_p)^{0.5}(W/d_v)^{0.35}(L^2 D/d_t^3)^{0.1} \qquad (4)$$

If the data compiled by Chilton, Drew and Jebens are plotted with Pratt's data, the combined slope, when plotted over a wide range of Reynolds numbers, is closer to the 0.62 value found by Chilton, Drew and Jebens than to the 0.5 value found by Pratt. This is, no doubt, caused by the restricted range of Reynolds numbers involved in Pratt's tests. It is recommended that Pratt's equations be used only within the range of Reynolds numbers involved in his tests, that is, from about 18,800 to 513,000 and with geometrically similar vessels.

Uhl—Uhl[11] extended the work of Chilton, Drew and Jebens to include a lower Reynolds-number range for jacketed vessels. This range included Reynolds numbers from 20 to 4,000.

The equipment used in Uhl's investigation was physically similar to that used by Chilton, Drew and Jebens. He used thermometers and thermocouples to measure the temperature of the vessel contents and the cooling water. He did not measure wall temperature, but used a calculated value for wall viscosity. Data are recorded both with and without baffles. The data obtained are correlated by using a modified Wilson plot and by assuming that the film coefficient for the inside of the jacket would vary as the speed of the agitator to the 0.67 power.

Uhl's results indicate the following relationship for Reynolds numbers in the 20 to 4,000 range.

$$\frac{h_j D}{k} = 0.415(\mathrm{Re})^{0.67}(\mathrm{Pr})^{0.33}(\mathrm{Vis})^{0.24} \qquad (5)$$

Dimensionless Groups Used in This Article—Table I

NOTE—Wherever applicable, these groups appear as the abbreviation instead of the full expression in the film coefficient equations of this article. This simplifies presentation of the equations and brings out more clearly the similarities among many of the equations.

Name of Group	Expression	Abbreviation*
Nusselt number	hD/k	Not used here
Reynolds number†	$L^2N\rho/\mu$	Re
Prandtl number	$c\mu/k$	Pr
Viscosity ratio	μ/μ_w	Vis

* AIChE-approved abbreviations, shortened here for simplicity are N_{Nu}, N_{Re} and N_{Pr}. Viscosity ratio does not have a recognized abbreviation.

† Special form of Reynolds number used in agitation.

It is apparent that for this range of Reynolds numbers the baffles have no effect on film coefficients. In the section on Turbines we shall see that, in the range above 4,000, the presence of baffles does affect film coefficients. We feel that for cooling the vessel contents the Uhl equation should give results very similar to those found by Chilton, Drew and Jebens, and that Uhl's results should be slightly higher for heating. It is recommended, therefore, that under heating conditions this equation be used only for Reynolds numbers that do not exceed 4,000.

Paddle Recommendations

While all of the conclusions reached are applicable for the particular vessels and Reynolds number ranges of the tests, we recommend that Uhl's data be used in the viscous region for jackets, and the data of Chilton, Drew and Jebens be used for coils and jackets in the turbulent range.

More research is needed, first, to determine the effect of baffles on film coefficients in the turbulent region; and, to find what influence the tubing diameter and coil spacing have in vessels which use coils.

PROPELLERS

Brown, Scott and Toyne—The only significant investigation involving heat transfer in jacketed vessels using propeller agitators was that of Brown, Scott and Toyne[5] who used large-diameter, slow-speed propellers. There have been no data published on heat transfer to coils in vessels using propeller agitators.

The tests performed by Brown, Scott and Toyne were in 750-gal. cast-iron nitrators, 5 ft. I.D., with hemispherical bottoms. The downward-thrust propellers were four-bladed, of 45° pitch. They were 2 ft. in diameter, located centrally in the vessel, and were driven at a speed of 120 rpm. In these tests, with the vessels used as nitrators, the heat of reaction was removed by running cooling water through the jackets of the vessels. Therefore, all tests were of the batch type.

The investigators measured temperatures by mercury-in-steel indicators contained within mild-steel thermometer wells. No side-wall baffles were used and no attempt was made to measure wall temperature.

These authors relied on the equations of Chilton, Drew and Jebens for the Reynolds number exponent of 0.67. The only variable introduced by them was the viscosity of the batch. Their data established that the film coefficient in vessels using propeller agitators varied as the viscosity to the −0.425 power and the exponent of the Prandtl number was therefore determined to be 0.25 rather than 0.33 used by Chilton, Drew and Jebens.

The equation resulting from this investigation is as follows:

$$\frac{h_j D}{k} = 0.54(\mathrm{Re})^{0.67}(\mathrm{Pr})^{0.25}(\mathrm{Vis})^{0.14} \qquad (6)$$

As the only variable introduced during these tests was viscosity, the writer suggests that the equation be applied only when dealing with geometrically similar vessels and propellers. Note that no attempt was made to correlate the obvious variable introduced by propeller pitch.

Pfaudler Co.—Recently, tests run in The Pfaudler Co.'s laboratory studied propeller agitation with coils in the vessel. Square-pitch propellers, with coils and straight tubes 1½ in. in diameter, were used. Water, oils and nitric acid were the fluids in the Pfaudler test, giving the following correlation:

$$\frac{h_o d_e}{k} = 0.078(\mathrm{Re})^{0.62}(\mathrm{Pr})^{0.33}(\mathrm{Vis})^{0.14} \qquad (7)$$

Thus far, no attempt has been made at Pfaudler to study the effect of propeller pitch, baffles or the use of propellers with jacketed vessels. In short, there are a number of questions still to be answered with regard to heat transfer with propeller agitation.

Much additional research is needed to provide a complete picture of heat transfer in vessels using propellers. No published literature has existed previously concerning heat transfer to coils and there is none concerning the influence of baffles in propeller-agitated vessels.

Research on the effect of propeller pitch and location is also needed.

ANCHORS

Brown, Scott and Toyne—Brown, Scott and Toyne[5] investigated heat transfer in vessels using anchor agitators. The vessels were the same type discussed above under propeller agitators. Two different anchors were used. The "A" unit had 5¼ in. clearance between the tank wall and the outside diameter of the anchor. The anchor's O.D. was 49¾ in. and its I.D. 43¾ in., giving an agitator width of 3 in. In the space between the tank and agitator, a 2-in. blowpipe acted as a baffle. Batch temperatures were recorded by a mild-steel thermometer well.

In the second, or "J" unit, a 1-in. clearance existed between the outside diameter of the agitator and the vessel wall. Agitator width was 3 in. Temperature was recorded by a mild-steel thermometer well. The "J" unit had a 6-in.-wide baffle located inside the anchor near the agitator shaft.

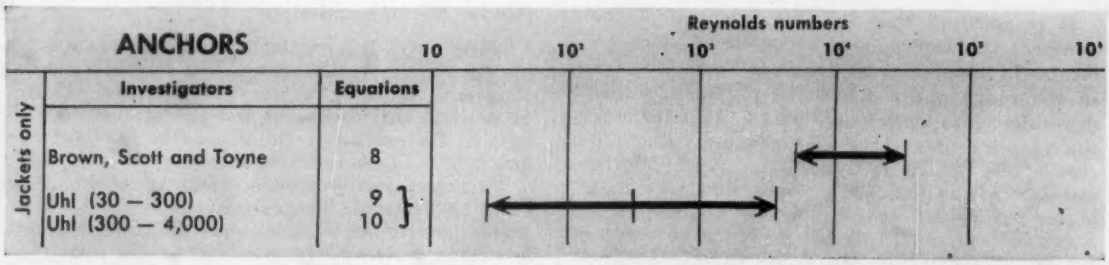
Agitator speed for both "A" and "J" vessels was 40 rpm. No wall temperatures were recorded.

The method of obtaining and correlating data was the same as that used by these investigators in testing propellers.

The equation resulting from the tests performed with anchor agitators by Brown, Scott and Toyne is as follows:

$$\frac{h_j D}{k} = 0.55(\mathrm{Re})^{0.67}(\mathrm{Pr})^{0.33}(\mathrm{Vis})^{0.14} \qquad (8)$$

Here, again, viscosity was the only variable, so it would be reasonable to use this equation for geo-



metrically similar equipment and for the investigators' Reynolds number range of 5,440 to 36,900.

Uhl—Uhl[11] also investigated the use of anchor agitators in the viscous region of flow. His vessel was fabricated of Monel with a 2-ft. I.D., 50-gal. capacity and standard dished head. He used thermometers and thermocouples to measure batch temperatures. Wall temperatures were calculated from the data. All tests were conducted without baffles.

The 2-in. blade-width agitator had a 22⅝ in. O.D. which resulted in a clearance of ⅛ in. between the agitator and tank. Over-all height of the anchor was 24 in.

The maximum Reynolds number used was only slightly over 4,000 because of vortexing of the liquid. All tests were of the batch type. However, small time intervals were used to give a process condition as close to the steady state as it was possible to achieve.

Uhl's investigations in this circumstance indicated that the film coefficient varied as the Reynolds number to the 0.67 power in the range of 300 to 3,000. However, in the range of 30 to 300, a curve with a slope of 0.5 was required to correlate the data.

The results of the work are expressed in the following equations.

For Reynolds numbers of 30 to 300:

$$\frac{h_j D}{k} = 1.0(\mathrm{Re})^{0.5}(\mathrm{Pr})^{0.33}(\mathrm{Vis})^{0.14} \qquad (9)$$

For Reynolds numbers of 300 to 4,000:

$$\frac{h_j D}{k} = 0.38(\mathrm{Re})^{0.67}(\mathrm{Pr})^{0.33}(\mathrm{Vis})^{0.14} \qquad (10)$$

These equations differ very little from that of Brown, Scott and Toyne for the range of Prandtl and Reynolds numbers involved. Because the constant of the Brown, Scott and Toyne equation is larger, $(N_{Pr})^{0.35}$ is used by them. Uhl's constant is lower but he uses $(N_{Pr})^{0.33}$.

Anchor Recommendations

Anchor agitators are often specified for heavy, viscous materials. Baffles are seldom used. For this reason the writer feels that Uhl's data can be applied for anchor agitators where the geometry is similar to that in Uhl's study.

Because coils are seldom used with anchor agitators, it is not surprising that there are no data at present.

TURBINES

Rushton, Lichtman and Mahoney—The first published work on heat transfer in vessels using turbine agitation was conducted by Rushton, Lichtman and Mahoney.[8] In this study, pipe baffles were used as the heat transfer surface in a 4-ft. diameter, cylindrical, flat-bottom tank which was 5 ft. high. Heating baffles were standard 1-in. galvanized iron pipe. Four pipes were connected with ell and tee fittings to form a baffle, and the heating medium was passed through the pipes in series.

Four of these baffles were arranged vertically and 90° apart around the circumference of the tank and each pipe baffle was positioned so as to extend 11 in. inward toward the center of the tank. A 1-in. clearance existed between the tank wall and the nearest pipe and clearance between the pipes was approximately 1.5 in. The purpose of vessel wall temperatures is not apparent from the description of equipment. No pipe wall temperatures were recorded.

Turbine agitation was provided by (1) a 12-in.-diameter turbine with four flat blades, and (2) a 16-in.-diameter turbine with six flat blades.

The study indicated that higher film coefficients resulted when turbine height was one-half the total liquid height. Turbine impellers are normally operated about one impeller diameter above the bottom of the tank and impellers are approximately one-third the diameter of the tank for best homogeneous mixing of tank contents. After determining that the highest coefficients were obtained at one-half liquid height, all subsequent runs were performed with this condition prevailing.

Since the only agitated liquid used was water, insufficient data was secured for determining the effect of Prandtl number on film coefficient. The data did indicate, however, that the following relationship existed:

For the 16-in., six-bladed turbine:

$$h_c = f(\mathrm{Re})^{1.0} \qquad (11)$$

For the 12-in., four-bladed turbine:

$$h_c = f(\mathrm{Re})^{0.7} \qquad (12)$$

Because the Reynolds number range was very restrieted, from 140,000 to 497,000, extropolation of J-factor vs. N_{Re} curve may lead to an erroneous result. Therefore, for the type of arrangement studied, the writer recommends that the data in Dunlap and Rushton[8] be used.

Cummings and West—Cummings and West[4] ran tests using retreating-blade turbine impellers, and both straight and 45° pitched-blade turbines. The

test vessel was 30 in. in diameter, of 100 gal. capacity, and constructed of Type 347 stainless steel. It had a standard ASME dished bottom head. Inside the vessel was a 2-ft. diameter, ten-turn, helical heating coil made of 1-in. O.D., 11-ga. stainless tubing. Coil turns were spaced 1.5 in. apart on centers, with two 4-in. gaps provided opposite the impeller blades. No baffles were used. Batch temperatures were measured using thermocouples. No wall temperatures were recorded.

Agitation was effected by a 12-in. diameter, six-blade, retreating-blade turbine impeller. Blade width was 2 in. and the turbine was placed 10 in. from the vessel bottom. In a number of runs, an additional turbine identical with the first was placed 10 in. above it, and in a few runs the 45° pitched-blade turbine was used. The latter turbine had six straight blades, each 5 in. in width. The pitched-blade turbine was also placed 10 in. above the bottom of the vessel. Normally, the agitator was rotated so that liquid was propelled toward the vessel bottom, but in a few runs rotation was reversed and the liquid was propelled upward.

Heat transfer tests were conducted under steady-state conditions, using six different liquids having widely varying properties.

These tests indicated that film coefficients would be the same at a given Reynolds number, whether one or two turbines were on the shaft. (It is possible that a significant difference in film coefficient would have been found if a larger vessel had been used.) The tests conducted with the pitched-blade turbine showed an approximate 10% reduction in film coefficient. No significant change in the film coefficient resulted from reversing the pitched-blade type turbine.

Cummings and West plotted their data with that of Chilton, Drew and Jebens for paddle agitation. The equations given by Cummings for the six-blade, retreating-blade impeller are as shown below:

For coils:

$$\frac{h_c D}{k} = 1.01(\mathrm{Re})^{0.62}(\mathrm{Pr})^{0.33}(\mathrm{Vis})^{0.14} \quad (13)$$

For jackets:

$$\frac{h_j D}{k} = 0.40(\mathrm{Re})^{0.67}(\mathrm{Pr})^{0.33}(\mathrm{Vis})^{0.14} \quad (14)$$

If the data by Cummings and West were plotted separately, however, higher values for the constant would result which would be applicable for turbine agitation with no baffles. Estimated values are:

For coils:

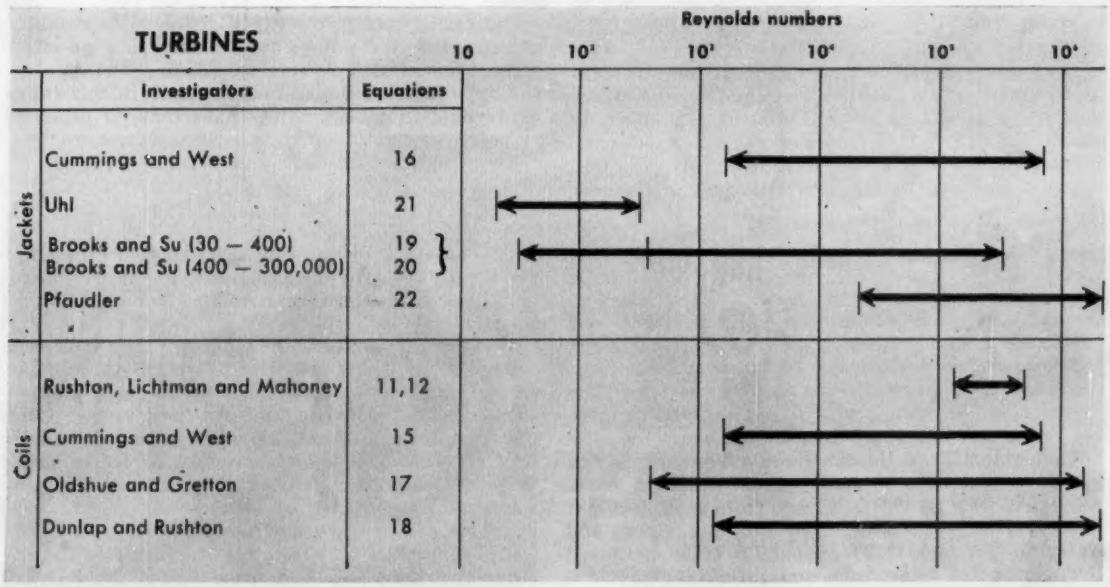
$$\frac{h_c D}{k} = 1.40(\mathrm{Re})^{0.62}(\mathrm{Pr})^{0.33}(\mathrm{Vis})^{0.14} \quad (15)$$

For jackets:

$$\frac{h_j D}{k} = 0.68(\mathrm{Re})^{0.67}(\mathrm{Pr})^{0.33}(\mathrm{Vis})^{0.14} \quad (16)$$

Equations (15) and (16) agree more closely than (13) and (14) with other published data on turbines.

Oldshue and Gretton—Oldshue and Gretton[6] obtained data on heat transfer using helical coils and turbine agitation. The equipment for these tests consisted of a flat-bottom tank 4 ft. in diameter, and a turbine agitator having six flat blades. Data were obtained using turbines with the following diameters: 12, 16, 20, 24 and 28 in. Four 4-in.-wide baffles were placed equidistant around the vessel. The ⅜-in. O.D. copper and 1¼-in. O.D. stainless helical coils were located so as to allow both steady- and unsteady-state operations. Both the copper and the stainless steel coils were wound on a 36-in. O.D., and the individual turns were alternated within the vessel. Spacing between turns was 1¾ in. for the copper tubing and either 3½ in. or 7 in. for the 1¼-in. stainless tubing. Thermocouples were embedded in



the tube wall for recording wall temperatures. Two liquids were used for testing purposes: Rochester city water and Gulf Crown turbine oil.

Data for the Reynolds number range from 400 to 1,500,000 gave the following correlation:

$$\frac{h_c d_c}{k} = 0.17(\mathrm{Re})^{0.67}(\mathrm{Pr})^{0.37}(\mathrm{Vis})^{m}\left(\frac{L}{D}\right)^{0.1}\left(\frac{d_c}{D}\right)^{0.5} \quad (17)$$

In Eq. (17) the value of the viscosity exponent m varies with the bulk viscosity, being about 0.97 at a bulk viscosity of 0.3 cp., and about 0.18 at a bulk viscosity of 1,000 cp.

Note that Oldshue and Gretton used diameter of the coil tubing rather than tank diameter in this correlation, as opposed to the practice of Chilton, Drew and Jebens and of Cummings and West.

The investigators stated that if the pitch of the coil was changed from $2d_c$ to $4d_c$, the film coefficient was reduced, depending on the viscosity.

When the baffles were located 1 in. off the wall, or inside, the film coefficient was 95% of that registered with the baffle directly attached to the wall.

Dunlap and Rushton—Dunlap and Rushton[5] extended the studies of Rushton, Lichtman and Mahoney on vertical tube baffles.

Equipment for these tests consisted of a flat-bottomed cylindrical tank 4 ft. in diameter and 5 ft. deep. Two three-tube baffles were located 180° apart. One baffle was used for cooling, the other for heating, to give steady-state conditions. The baffles were constructed of three sections of standard 1½-in. galvanized iron pipe connected in parallel. Thermocouples placed in the pipe wall measured wall temperatures. The liquid temperature was measured by a thermocouple probe immersed in the liquid. Tank construction permitted the symmetrical addition of two, four or six dummy baffles to the system. Liquid depth was maintained at 4 ft.

Test data were also obtained using a geometrically similar vessel scaled down to 2:1—except that the baffle tubes were standard ½-in. pipe.

Flat, four-bladed turbines, centered on the vertical axis of the vessel, were used to provide agitation. The impellers were located midway between the tank bottom and the liquid surface level.

The method of film coefficient calculation was similar to that used by Chilton, Drew and Jebens. However, Dunlap and Rushton included the effect of turbine-diameter, tank-diameter ratio and also the effect of baffles which cause turbulence.

The correlation obtained by Dunlap and Rushton is:

$$\frac{h_c d_c}{k} = 0.09(\mathrm{Re})^{0.65}(\mathrm{Pr})^{0.3}(\mathrm{Vis})^{0.14}\left(\frac{L}{D}\right)^{0.33}\left(\frac{2}{B}\right)^{0.2} \quad (18)$$

The correlation is appropriate for the physical system described above, in a Reynolds number range from approximately 1,300 to approximately 2,000,000.

Brooks and Su[1]—These men investigated heat transfer with turbine agitation in baffled and nonbaffled vessels. This investigation covered a Reynolds number range of 30 to approximately 300,000.

The equipment in this case was a 30-gal. Type 316 stainless-steel vessel, with standard dished head. Agitation was provided by a turbine with six flat blades. The vessel was piped for both steam and water in the jacket. Thermometer wells measured temperature at jacket inlet and outlet.

Critical dimensions of the vessel and impeller included: impeller diameter, 6 in.; tank diameter, 20 in.; liquid height, 21 in.; and impeller height from the bottom, 6 in.

Tests were made with water, SAE 30 and 50 oils and 43° Bé. corn syrup. These tests were conducted successfully with the following: No baffles, one, two diametrically opposite and, finally, four baffles. Speeds of the impeller ranged from 30 to 450 rpm.

Brooks and Su's method of correlating the data is similar to that used by Uhl.[11]

The equations the authors correlated from the data are as follows:

For unbaffled vessels and baffled vessels with Reynolds numbers of 30 to 400:

$$\frac{h_j D}{k} = 0.54(\mathrm{Re})^{0.67}(\mathrm{Pr})^{0.33}(\mathrm{Vis})^{0.14} \quad (19)$$

For baffled vessels (either one, two or four baffles) with Reynolds numbers of 400 to 300,000:

$$\frac{h_j D}{k} = 0.74(\mathrm{Re})^{0.67}(\mathrm{Pr})^{0.33}(\mathrm{Vis})^{0.14} \quad (20)$$

Data obtained by Pfaudler agree with this equation for larger sized (1,000 gal.) vessels with four baffles; however, there is some doubt of the validity of this equation in a large vessel that has only one or two baffles. Additional tests are required for verification.

Uhl—Uhl[11] performed tests using a 12-in.-diameter turbine (flat bladed and pitched, with six blades).

His equipment consisted of the same tank as that used for the paddle and anchor agitator tests. The agitation mechanism used was a flat, six-bladed 45° pitched turbine. Turbine diameter was 12 in. Tests were run with the turbine at two different positions in the vertical plane. The lower position was at a distance of 4 in. from the bottom of the vessel. The upper position was about 11 in. from the bottom of the vessel.

The method of correlating the data was identical to that used in the Paddle and Anchor agitator equations.

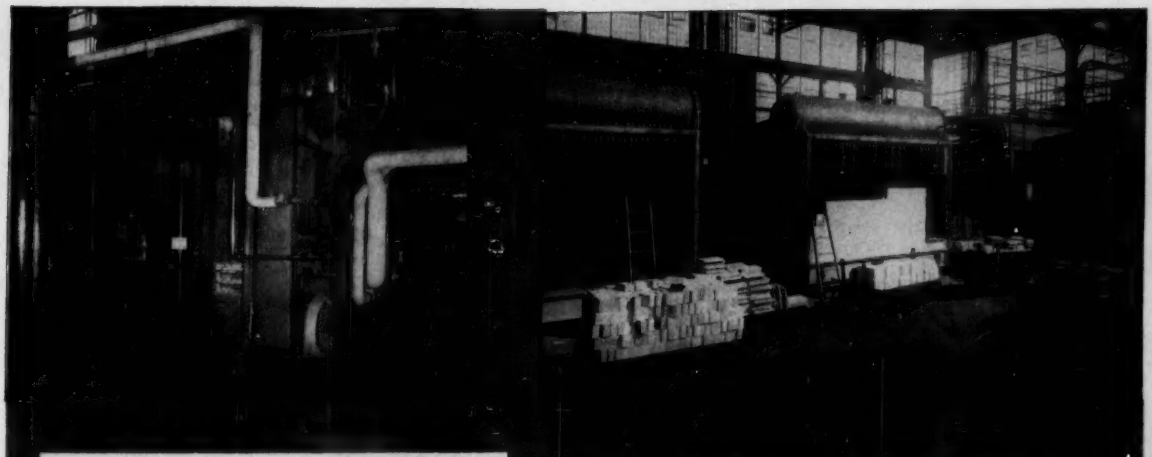
Uhl found that, in the range of Reynolds numbers investigated (from 20 to 300), baffles have no effect on heat transfer. This corresponds to power data for this type impeller which indicate that, in this range of Reynolds numbers, baffles have little or no effect on power consumption.

The equation Uhl derived is as follows:

$$\frac{h_j D}{k} = 0.535(\mathrm{Re})^{0.67}(\mathrm{Pr})^{0.33}(\mathrm{Vis})^{0.24} \quad (21)$$

This agrees rather well with the data of Cummings and West. The data also indicate that at the low position during the heating runs, the constant in the equation is 0.44.

Pfaudler—A number of unpublished tests have been conducted at The Pfaudler Co. with a three-blade, retreating-blade turbine impeller in both glassed-steel and alloy construction. We used vessels ranging from 30 to 1,000 gal. capacity, with one baffle in smaller vessels, and sometimes two baffles in larger vessels. The test liquids ranged from water and water-like materials to heavy viscous organics. Reynolds numbers varied from 20,000 to over 2,000,000. The method of correlating the results was similar to that used by Uhl and by Brooks and Su. For



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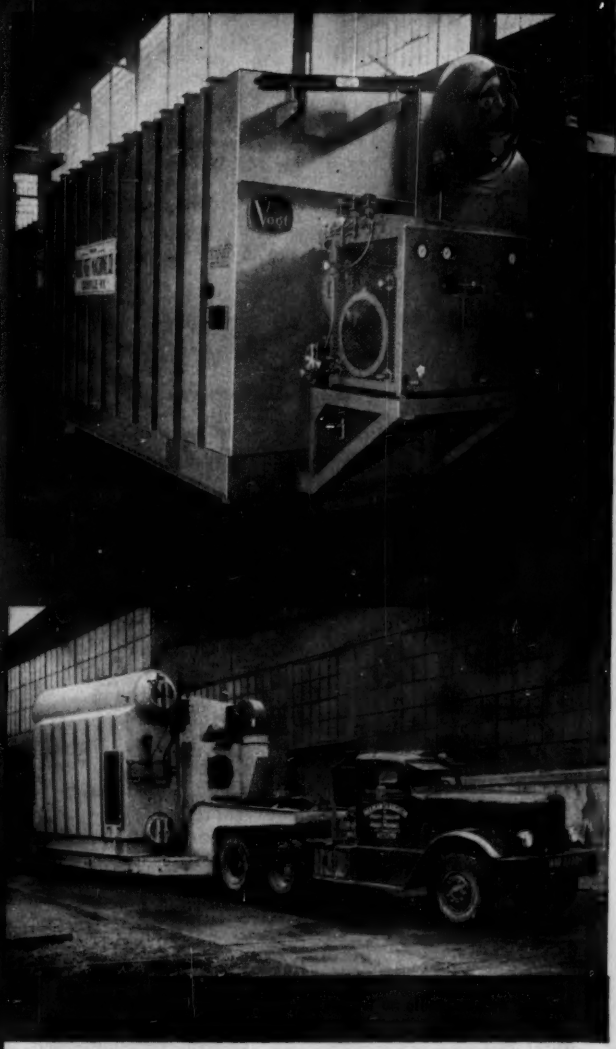

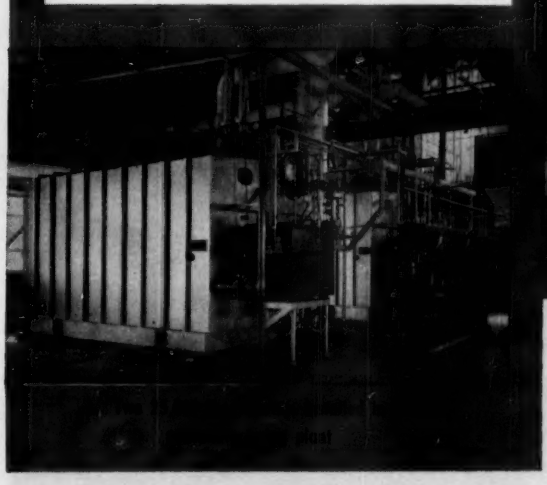

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Summary of Recommendations for Film Coefficient Equations for Turbines—Table II

Transfer Surface	Turbine Type	Investigators	Equation No.
Jacket	6-blade retreating-blade turbine	Cummings & West as interpreted by author	16
Jacket	6-blade, flat	Brooks & Su	19, 20
Jacket	6-blade, 45° pitched	Uhl	21
Jacket	3-blade retreating-blade turbine	Pfaudler	22
Coil	6-blade retreating-blade turbine	Cummings & West as interpreted by author	15
Coil	6-blade, flat	Oldshue & Gretton	17
Verticle tube baffles	4-blade, flat	Dunlap & Rushton	18

glassed-steel impellers in jacketed vessels the equation obtained was as shown in the equation below:

$$\frac{h_j D}{k} = 0.33(\mathrm{Re})^{0.67}(\mathrm{Pr})^{0.33}(\mathrm{Vis})^{0.14} \qquad (22)$$

Our tests indicated that the proper constant to be employed when using alloy impellers is 0.37 instead of the 0.33 used for glassed steel. This difference may be attributed to greater slippage occurring around the curved surfaces of the glassed-steel impeller than occurs around the sharp corners of the steel impeller. No attempt has been made as yet to determine the effect obtained when coils are used with glassed-steel impellers.

The tests with alloy impellers were conducted using finger-type baffles. This baffling consists of a straight post extending down from the top head, with two fingers protruding out from this post. Although the alloy impeller has been used in vessels with side-wall baffles, there are no data available at this time. Until data are obtained for this condition, the equation obtained with the stainless impeller with finger baffles will probably result in reasonable accuracy.

Turbine Recommendations

The published data have covered many turbine configurations, including straight-blade, curved-blade, angled-blade, six-blade and three-blade types, but no satisfactory method of correlating the data for the different configurations exists. A possible exception here is a power relationship. Therefore, it is difficult to recommend a single equation. It appears more prudent to choose an equation for each specific condition.

For coils, use of the tubing outside diameter as the correlating dimension in the Nusselt number would seem correct; this was the procedure used by Oldshue and Gretton. For convenience, the types of turbine and heat transfer surface, and the recommended equations to be used with them are summarized in Table II.

This article has covered all important publications in the field of heat transfer in agitated vessels. It has also added new data which may be used on propellers and turbines. Its charts give the recommended equations for use in specified applications and show the Reynolds number range for which each equation is applicable.

Future data should, we hope, furnish the basis for a more comprehensive method of correlation. Perhaps a correlation between power and heat transfer will be useful. At present, however, there is no single equation that will enable the engineer to find film coefficients for all types of agitators and vessel configurations.

Nomenclature (Consistent Units)

- B Number of baffles.
- c Specific heat.
- d_c Mean diameter of coil.
- d_o External diameter of tubing used in coil.
- d_g Gap between individual turns of coil.
- d_p Over-all height of coil.
- D Vessel diameter.
- h_c Agitated film coefficient when using coils.
- h_j Agitated film coefficient when using jackets.
- k Thermal conductivity.
- l_s Length of side of square vessel.
- L Agitator diameter.
- m Exponent depending on bulk viscosity.
- N Agitator speed.
- W Width of stirrer blade (sum of widths when using two or more blades).
- μ Viscosity.
- μ_w Viscosity at heat transfer barrier.

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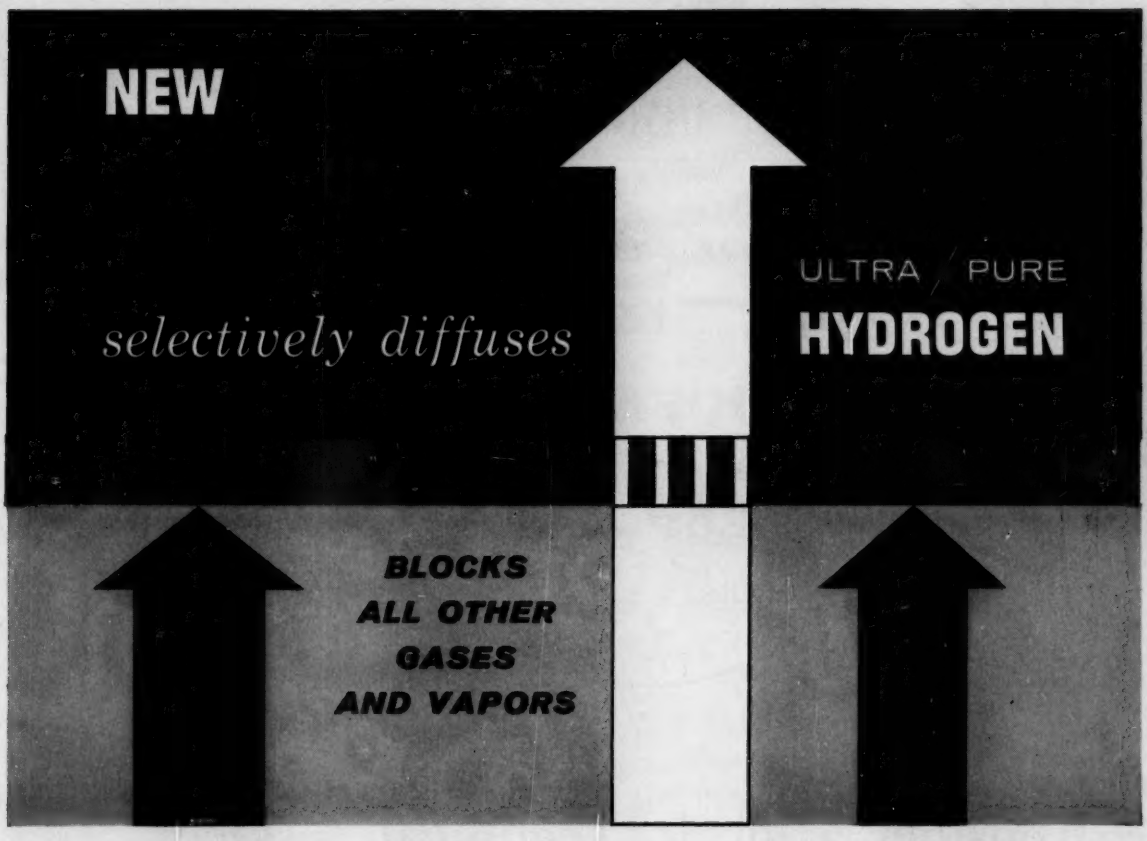

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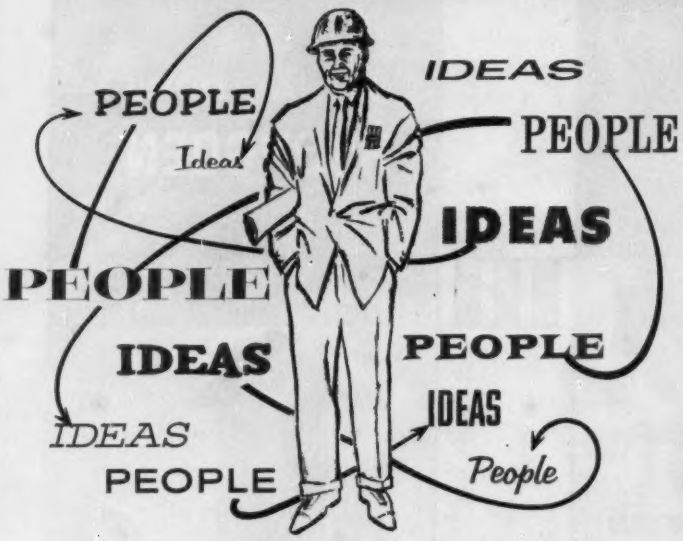

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Dictionaries may define technical service as, "a sales aid providing technical assistance to a customer for or during the use of a product." However, a clearer picture is obtained by examining the "technical" and "service" separately.

The technical aspect is concerned with chemical and engineering principles applied to the "how" of a product (e.g., how does one use it?). This, of course, differentiates it from the commercial aspects which are concerned with who, when and where.

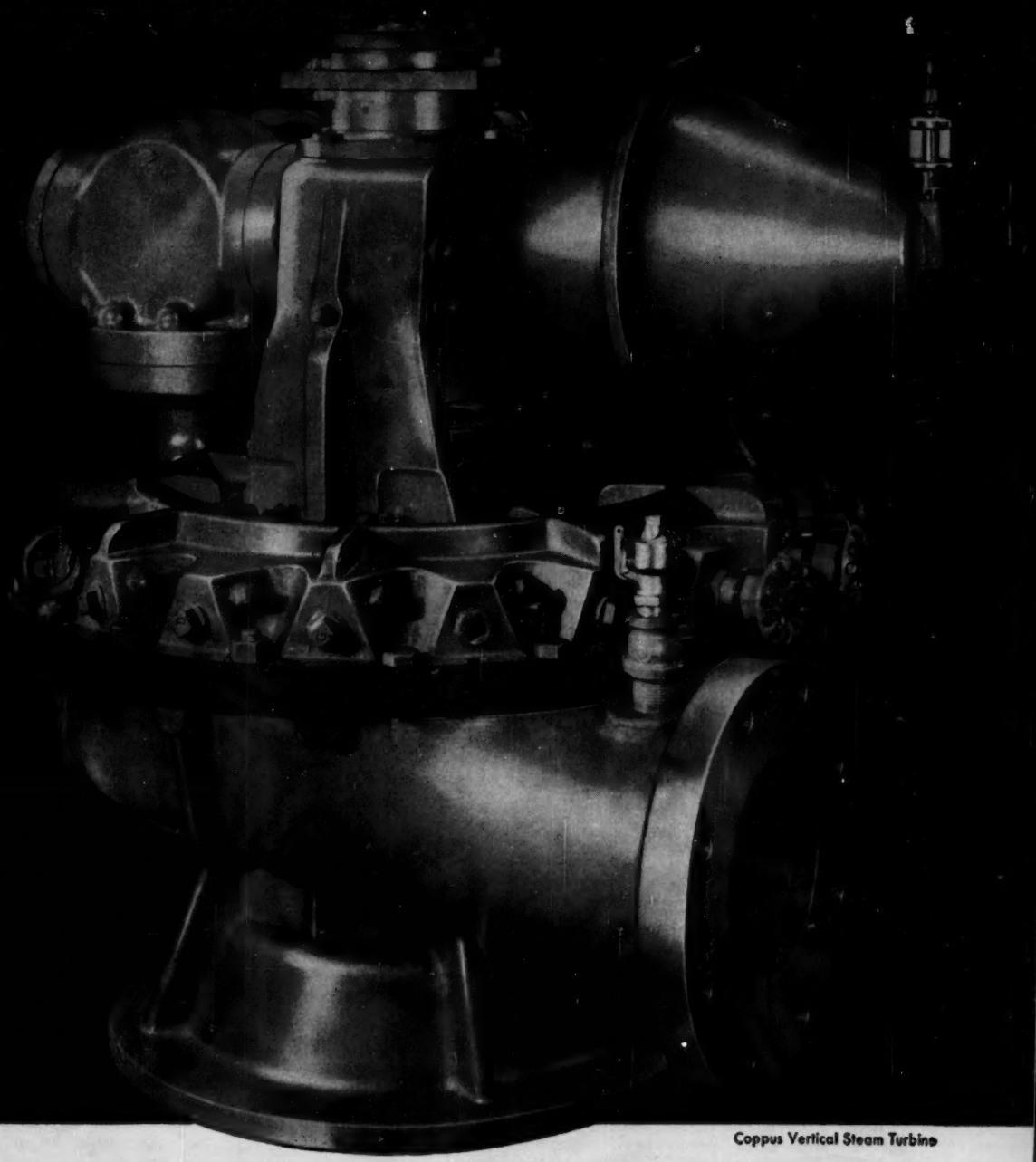
Service is difficult to define because it denotes effort for someone else and few like to feel that their efforts are being spent on others' problems. Service concerns itself with the problem of developing for or with a customer, products, forms or methods by which materials can be used for customer's profit. The work can be both creative and productive.

One of the main satisfactions is that you see the results of your effort materialize into successful products.

►**Why It's Needed**—Selling is often thought of as price and quality. We know that manufacturers of basic commodities sell at about the same price with only a slight variation in quality among producers.

This equality comes about because of standards and controls set by governmental agencies, standardization societies and trade associations. When superior quality is offered, it's us-

COPPUS BLUE RIBBON PRODUCTS



Coppus Vertical Steam Turbine

THE MARK OF QUALITY — There's no better test of a turbine's quality than performance. And the new, ruggedly designed, power-packed Coppus Turbines pass all performance tests with top honors! Small wonder. Coppus quality is literally designed and built into them. Their super stamina is the end-product of painstaking craftsmanship, finest materials and methods, thorough testing and control. Each truly deserves its Blue Ribbon . . . assurance of *complete* reliability.

Typical Coppus Blue Ribbon features are: *totally enclosed governor . . . totally enclosed and independently operated safety trip . . . easily replaceable packing and bearings . . . multiple steam nozzle control . . . brake rim for added safety . . . wide bucket "L" type wheel (optional) for minimum water rate.* You get higher efficiency operation . . . less down time . . . lower maintenance costs.

Coppus Turbines are built to customers' specifications, including API and NEMA standards. Send for Catalog 200. Get complete details on Coppus Turbines. Sizes from 1 HP to 250 HP. Write COPPUS ENGINEERING CORPORATION, 228 Park Avenue, Worcester, Mass. Sales Offices in *Thomas' Register*.

COPPUS
STEAM TURBINES

Analysis of an Engineering Service Problem

Technology	Steel makers use MgO to coat sheet steel (special high-Si grade) for use in fabricating transformer cores. MgO coating applied in water slurry. Steel sheets then dried, coiled and annealed in a high-temperature H_2 atmosphere. Annealing requires about a week.
Sales Criteria	Finished product sold on the basis of critical tests of its electrical properties.
Request for Service	Steel companies encountered extreme variability in their coating operations and in the electrical properties of the coated steel.
Engineering Analysis	MgO hydrates on contact with H_2O. Hydration rate depends on activity of MgO, which varies with the source of supply. Exposure to air or moisture alters activity of MgO supplied. The MgO performs several functions: keeps the coils from sticking together; purifies the steel during the anneal; and finally reacts with the Si in the steel to form a glass-like coating of magnesium silicate.
Task Assigned	Established the requirements for a satisfactory MgO. Plan and coordinate research, development and plant-scale projects needed to produce a satisfactory product. Show the customer how to use it.

ually associated with additional costs.

Ability to convince a customer that his problems and interests are yours can make a difference in selling when price and quality cannot. Proper knowledge and use of this sales psychology, makes the technical service function an important factor in the purchasing decision.

▶These Are the Objectives—How does a technical service group operate? First, let's list the objectives of such a group:

1. Assist in the introduction of new chemicals which substitute for those already in use.
2. Introduce new uses for existing products.
3. Introduce new chemicals for new uses.
4. Handle customer complaints.

Technical service may originate from two other organizations, sales or product development. The scope and effort of each group can therefore become complicated and it really depends on the nature of the product and the type of problem that must be solved.

Since the product development function is charged with the responsibility for developing new products and applications, it can draw on many talents and facilities to pursue its problems in depth. Therefore, the product development department can make its most effective contribution on new products and new applications during their initial introduction to the trade.

The sales department, lacking such depth facilities, serves best on uses or products where no laboratory investigation is necessary. Transfer of problems from sales to technical service becomes evident as the scope and urgency change.

Functioning of technical service groups and their relationship to sales and research can be explained by using some actual cases. Here's one that we have worked on.

Development of new animal and poultry feeds has involved the addition of medicating agents to grains in micro quantities. During the establishment of a product, studies are conducted on concentration and efficacy of the additive, particle size, stability, segregation, dustiness, general flow properties of the mixture, packaging and storage techniques.

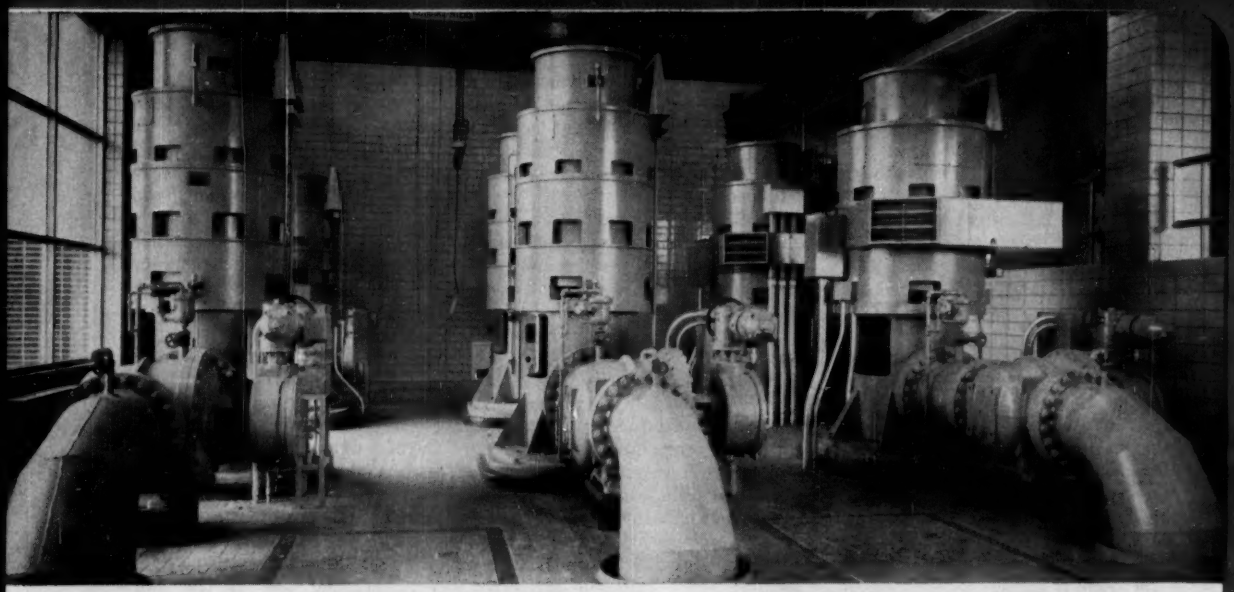
Knowledge of these factors obtained in the laboratory must be translated into field application.

Many of the active materials go through a final blending operation at the feed plant, where reductions in concentration of the active ingredients from 25% to 0.2% are practiced. Often additional supplements are added. These must not upset the compatibility of the blended system.

All of these operations call for control over the type of blender, blending time, dusting, etc. The supplier must be in a position to guarantee the final feed supplement. Engineering talents are used to demonstrate correct practices with each product and to insure that the feed manufacturer offers for sale a product with guaranteed properties.

The technical service field man can be called upon to solve a dusting problem by specifying certain mill practices, duct and ventilation design and conveying systems. He can assist in solving problems of segregation by exploring blending practices, ingredients added, or build-up of electrostatic charges.

When additional ingredients are required to solve a problem, the technical service man might work in the laboratory to develop a solution. He has full knowledge of the laboratory effort and



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Specifications

RAW WATER—10 Layne Gravel Wall Wells with Layne 18-8 Stainless Steel shutter screen and 10 Layne deep well pumps. 2800 GPM — 65 ft. TDH, 75 hp—440 Volts— 1750 RPM, located in two banks pumping to the filter beds. Pumps were installed 15 feet above ground level for flood protection.

FILTERED WATER—Six Layne high service pumps boosting filtered water into distribution system. Five are 12 MGD-285 ft. TDH, 700 hp—4160 volts—1185 RPM. Two are variable speed units. The sixth Layne Pump is a 6 MGD-285 ft. TDH, 400 hp—4160 volts—1185 RPM. All pumps operate through the central control panel.

City of Springfield, Ohio

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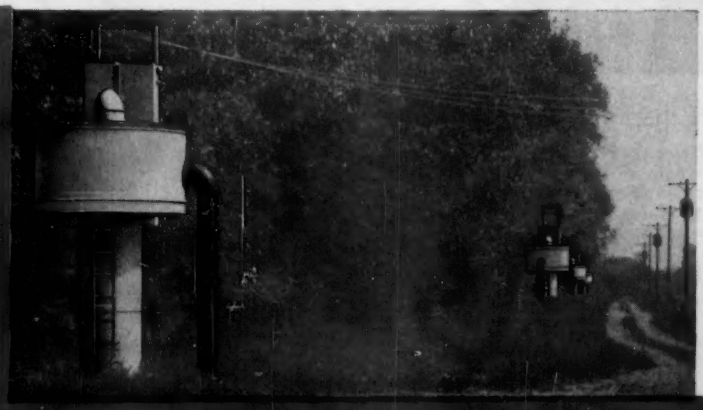

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scale-up factors, hence is a readily available consultant.

For the small customer who does not have his own engineering staff, technical service may include the design and layout of entire feed-handling systems.

▶**A Real Challenge**—The task of introducing new products for new uses is always a real challenge.

The aim of a new product is to make a profit for the seller as well as the buyer. This can only come about through proper use. Since familiarity in depth does not exist with new products, the technical service staff must be "in attendance" and oversee, as much as possible, the work of the potential customer.

A new product once it gets off the track is extremely difficult to right.

Very often direct assistance to the customer's research staff or pilot-plant demonstrations point up the need for new data. The technical service field engineer must be able to evaluate these needs, spell out the time and effort required to obtain this information, interpret new information and again set out to guarantee performance.

Most of these problems are hardly distinguishable from the classical scale-up problems which the development, design or production engineer faces every day. Translation, and extrapolation from laboratory to plant scale, from plant to plant, is often left to the direct responsibility of the field man.

▶**Developing a New Use**—Developing a new use for a chemical is another kind of problem which the technical service engineer is often asked to solve. We've analyzed such a problem in tabular form above.

In this case, after several years of research effort, we developed a satisfactory product. But then our laboratory work had to be confirmed by tests in the steel mills, since mill conditions are difficult to duplicate on a small scale.

So we sent our technical service engineers into the mills to be present during critical operations. They presented what they had to offer to the steel companies and advised their employer on further research on production efforts that would be needed to satisfy the customers' needs.

▶**Knows the Customer**—A good technical service engineer knows his customers and their problems. He is familiar with the economics necessary for successful solutions and, in addition, he is up-to-date on the technological changes in his field.

He is, in fact, his employer's expert in the customer's technology. This puts him in the unique position of being qualified to suggest and appraise research and development programs.

Here's an interesting problem that was initiated by a technical service engineer and is now in the research stage.

A small, but steady, customer was visited by the field engineer who found that the product was being used in a way never before considered for this material. Careful exploration of the literature and company files revealed that the customer either had found a new use or was mistaken about the advantages realized from the product.

Later, the use of the same product to reduce tackiness in certain rubbers came to the company's attention. A note of similarity in the mode of action of the product in both end uses was detected by the technical service engineer.

If these applications are in fact related by the additive's property of reducing the effects of light degradation, then entirely new and profitable markets may open up.

As a result of these observations by a technical service engineer, a research program has been started to explore this property for additional commercial applications.

▶**Growth and Profit**—We have presented here only a part of the position played by the technical service engineer in guaranteeing the growth and continued prosperity of the organization that employs him.

Since it calls for a display of technical talent and creativity, cost consciousness with knowledge of operations and products, technical service offers a limitless challenge to the chemical engineer.

It provides a unique and satisfying opportunity for the engineer who likes to work with ideas as well as with people. It provides an opportunity to move into a staff management responsibility without leaving all of your engineering training behind you.

Technical service does indeed broaden the horizon for the engineering discipline.

HENRY B. LANGE is head of the industrial chemical section, product development dept. of Merck's chemical div. in Rahway, N. J. He has studied at Ohio State Univ. and Newark College of Engineering and holds the M. S. degree in chemical engineering. Lange is a member of ACS and AIChE. His previous publications cover the application of statistics to production troubleshooting.

WILLIAM H. CROM, is sales manager of Merck's marine magnesium div. in Rahway. He is an engineering graduate of Princeton Univ., and has served as a chemical engineer with Merck since 1951. Before that he was associated with M. W. Kellogg, Carl Buhr Inc. and the Austin Co., all in New York. Crom is a member of ASME, the ACS Rubber Group and the Chemical Industries Assn.

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No. 38: Labor Factors; A.C. and D.C. Motors

E. Wayne Michel, Member AACE, Baton Rouge, Louisiana

Installation Labor for Mounting Motors*

So far, in this series on labor factors for electrical installations, we have covered motor starters (*Chem. Eng.*, May 2, '60, p. 142; June 27, '60, p. 134). Now in this Cost File we turn to a.c. and d.c. motors. As before, these units represent work of an average journeyman and are based on experience in Gulf and West Coast.

In the man-hr. tabulations below, units include placing or hoisting to machine (12-ft. maximum height). Add for additional hoisting and for fastenings and supports. (Electrical connections are included in starter units of two Cost Files cited above.)

* With base, pulley or coupling.

Mounted on : F = Floor, W = Wall or machine, C = Ceiling

A.C.; 60 cps.; 3 and 2 phase; 220, 440 or 550 v.

	720 RPM.			900 RPM.			1,200 RPM.			1,800 RPM.		
HP.	F	W	C	F	W	C	F	W	C	F	W	C
1	4.5	6.4	8.2	3.7	5.2	6.7	3.0	4.2	5.7	3.0	4.2	5.7
1½	4.5	6.4	8.2	4.5	6.4	8.2	3.4	4.9	6.0	3.4	4.9	6.0
2	5.2	7.5	9.7	4.5	6.4	8.2	3.7	5.2	6.7	3.7	5.2	6.7
3	6.7	9.7	12.0	5.2	7.5	9.7	4.5	6.4	8.2	3.7	5.2	6.7
5	8.2	12.0	15.0	6.7	9.7	12.0	5.2	7.5	9.7	4.5	6.4	8.2
7½	10.5	15.0	19.5	8.2	12.0	15.0	6.7	9.7	12.0	5.2	7.5	9.7
10	15.0	21.0	27.0	10.5	15.0	19.5	8.2	12.0	15.0	6.7	9.7	12.0
15	15.7	22.5	28.5	15.0	21.0	27.0	10.5	15.0	19.5	8.2	12.0	15.0
20	19.5	27.0	34.5	15.7	22.5	28.5	12.0	16.5	21.0	10.5	15.0	19.5
25	21.0	30.0	37.5	19.5	27.0	34.5	15.7	22.5	28.5	12.0	16.5	21.0
30	22.5	31.5	40.5	21.0	30.0	37.5	19.5	27.0	34.5	15.0	21.0	27.0
40	23.2	33.0	43.5	22.5	31.5	40.5	21.0	30.0	37.5	19.5	27.0	34.5
50	34.5	48.0	....	25.5	36.0	....	25.5	36.0	....	25.5	36.0	....
60	39.0	54.0	....	34.5	48.0	....	30.0	42.0	....	30.0	42.0	....
75	45.0	....	....	39.0	....	....	36.0	....	....	36.0	....	....
100	57.0	....	....	45.0	....	....	39.0	....	....	39.0	....	....
125	87.0	....	....	57.0	....	....	43.5	....	....	43.5	....	....

A.C.; 60 cps.; 3 and 2 phase; 440 or 550 v.

150	87.0	....	....	57.0	....	....	43.5	....	....	43.5	....	....
175	87.0	....	....	87.0	....	....	51.0	....	....	51.0	....	....
200	96.0	....	....	87.0	....	....	51.0	....	....	51.0	....	....

Note: For 25 cps., increase units 15%.

D.C.; 115/230 v. constant speed; shunt, series or compound wound.

	690 RPM.			850 RPM.			1,150 RPM.			1,750 RPM.		
HP.	F	W	C	F	W	C	F	W	C	F	W	C
1	5.2	7.5	9.7	4.5	6.4	8.2	3.4	4.9	6.0	3.4	4.9	6.0
1½	5.2	9.0	9.7	5.2	7.5	9.7	4.5	6.4	8.2	4.5	6.4	8.2
2	6.7	9.7	12.0	5.2	7.5	9.7	4.5	6.4	8.2	4.5	6.4	8.2
3	10.5	15.0	19.5	6.7	9.7	12.0	5.2	7.5	9.7	4.5	6.4	8.2
5	10.5	15.0	19.5	10.5	15.0	19.5	6.7	9.7	12.0	5.2	7.5	9.7
7½	12.0	16.5	21.0	12.0	16.5	21.0	10.5	15.0	19.5	6.7	9.7	12.0
10	15.0	21.0	27.0	15.0	21.0	27.0	12.0	16.5	21.0	10.5	15.0	19.5
15	22.5	31.5	40.5	16.5	24.0	30.0	15.7	22.5	28.5	12.0	16.5	21.0
20	22.5	31.5	40.5	22.5	31.5	40.5	16.5	24.0	30.0	15.7	22.5	28.5
25	25.5	36.0	46.5	22.5	31.5	40.5	22.5	31.5	40.5	16.5	24.0	30.0
30	30.0	42.0	54.0	25.5	36.0	46.5	22.5	31.5	40.5	16.5	24.0	30.0
40	39.0	54.0	70.5	30.0	42.0	54.0	22.5	31.5	40.5	22.5	31.5	40.5
50	55.5	78.0	....	39.0	54.0	....	25.5	36.0	....	22.5	31.5	....
60	58.5	82.5	....	55.5	78.0	....	30.0	42.0	....	22.5	31.5	....
75	69.0	96.0	....	58.5	82.5	....	39.0	54.0	....	25.5	36.0	....
100	81.0	....	....	58.5	....	....	55.5	....	....	39.0	....	....
125	102.0	....	....	81.0	....	....	58.5	....	....	55.5	....	....
150	115.5	....	....	103.5	....	....	81.0	....	....	58.5	....	....
175	129.0	....	....	115.5	....	....	103.5	....	....	81.0	....	....
200	141.0	....	....	129.0	....	....	115.5	....	....	103.5	....	....

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Case histories of economies resulting from Fluoroflex-T are being increasingly reported, citing ease and speed of installation with prefabricated lengths, lower checkout time, decreased maintenance, long equipment life, and elimination of process headaches and downtime. One plant equipped with Fluoroflex-T, in fact, reported savings of $60,000 per month in costs of maintenance, downtime, and product loss.

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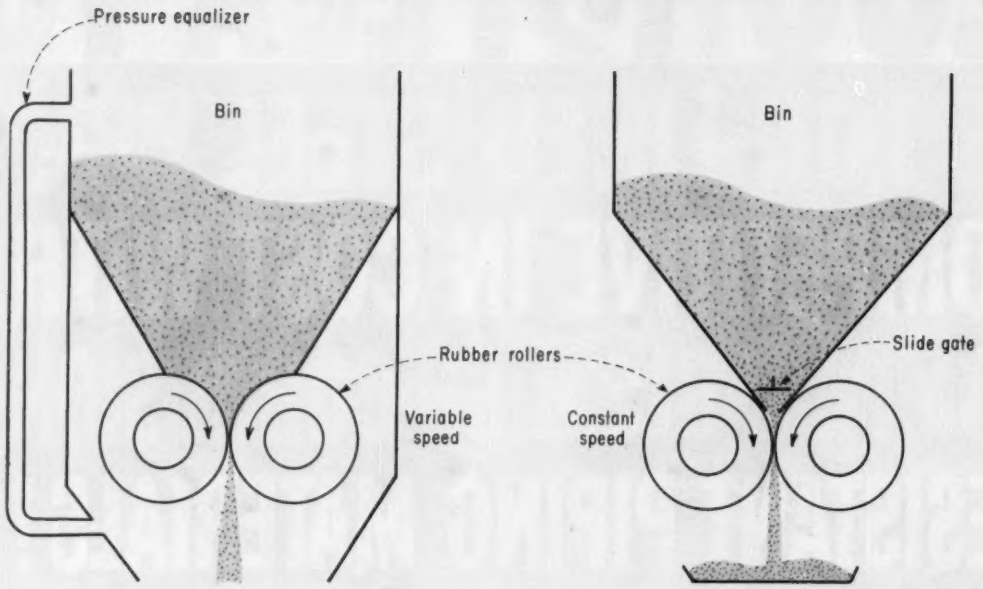


Roll Feeder Controls Solids Flow

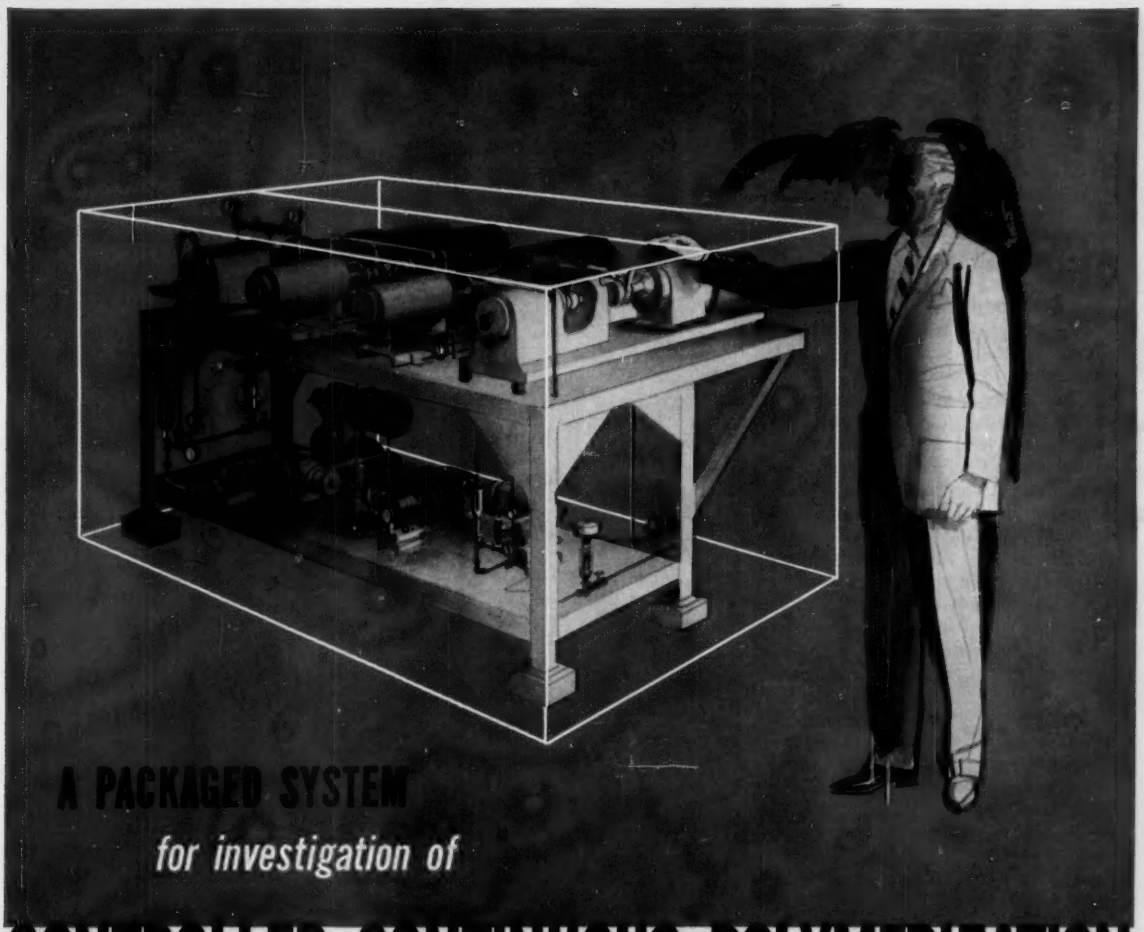
Soft rubber rollers provide simple and cheap means of metering free-flowing solids.

★ Winner of the June Contest by
Sam A. Jones
International Mineral and Chemical Corp., Mulberry, Fla.

Have you ever been frustrated when trying to feed a small volume of free-flowing solids at a constant rate with a screw or other positive-displacement equipment?

We have devised a feeder which feeds solids at a controlled and accurate rate from grams to pounds per minute. The feeder consists of a pair of soft rubber rollers driven by a variable speed motor. (The rollers can be covered instead with other resilient material, such as asbestos.) The feeder is particularly effective at supplying a measured flow of solids to a pneumatically conveyed stream, as well as many other jobs.

Very free-flowing material which might flood through a screw or other feed device can't exceed the set rate through the roll feeder because the rollers, always in contact with each other, provide a positive seal. The feeder will inject solids into a pressurized system, too, if a pressure equalizing line is placed around the rollers. This arrangement is shown in the above illustration, left side. The solids must



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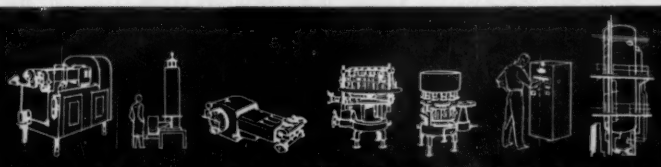

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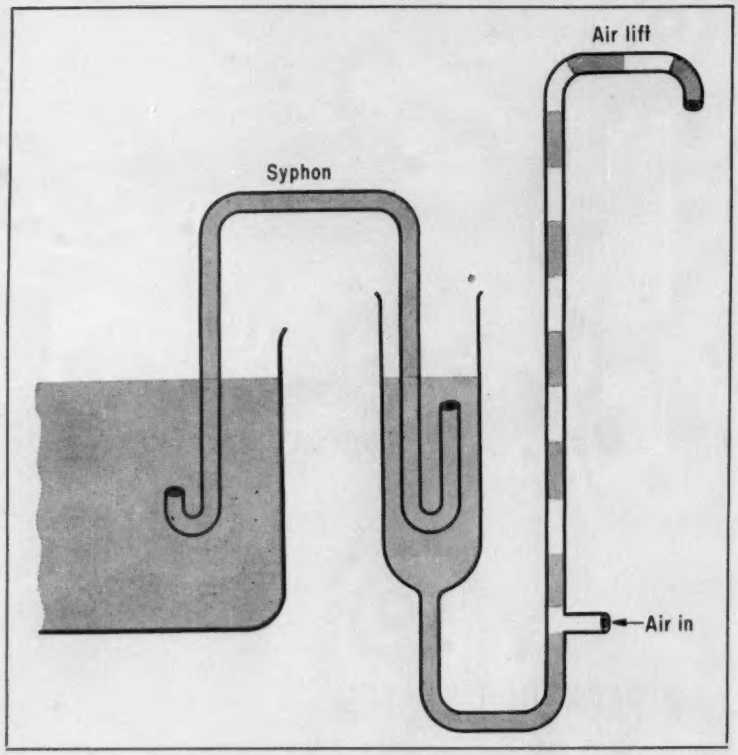
then be lock-hoppered to feed the rolls. The feed rate is completely independent of the height of solids in the roller feed bin.

Operating over a wide range of roll speeds, the unit shows less than 2% variation in throughput at any given setting. Calibration rates on a given feed material are reproducible within the accuracy of the variable speed drive settings, provided particle size remains constant.

The feeder can be used for many solids-handling jobs. For example, what is the best way to take a continuous sample from a solids process stream? The roll feeder is good. Place it anywhere the solids are flowing by gravity, set the speed for the desired amount, come back after any time interval to pick up the representative sample. The feeder can also meter a solids flow into a liquid or another solids stream at a carefully controlled rate.

Variable lengths or diameters of rollers can be used—we have had feeders in operation with 1- to 6-in. rollers up to 18-in. long. Power requirements of the unit are quite low since the rollers just barely touch each other.

Another method we have found to control the feed rate is to vary the effective length of the rollers instead of the drive speed. A slide gate is installed in the bottom of the hopper which supplies solids to the rolls. By moving the gate back and forth, we can control the delivery rate. Both methods of control are shown in the illustration.



Air Lift Operates From Syphon

A. A. Mayling
Chief Chemist, Consolidated Denison Mines Ltd., Spragge, Ont., Canada

Transferring liquid from one open reaction vessel operating under reflux to another at a lower level can easily be accomplished with a self-priming syphon. When the other vessel is at a higher level, however, a pump is required to make the transfer. For laboratory work, the simplest pump is an air lift. It is not possible, however, to operate an air lift on a normal type of syphon because the surges of air back up the feed leg, breaking the syphon.

To do this job, I used the airlift system shown in the illustration. Here, the syphon discharges into a seal chamber which, in turn, feeds the air lift. Air cannot back up and break the syphon because of the seal. In the work I was doing, it was necessary to avoid excessive evaporation, so the syphon down leg was enclosed in a cooling water jacket and the air feeding the air lift was saturated with the solvent by passing it through a scrubber. For another application see *Chem. Eng.*, p. 164, July 13, 1959.

Coming Sept. 19: Chart for Compression and Expansion Temperature

By C. A. Kleppe, Winner of the Mid-summer Contest

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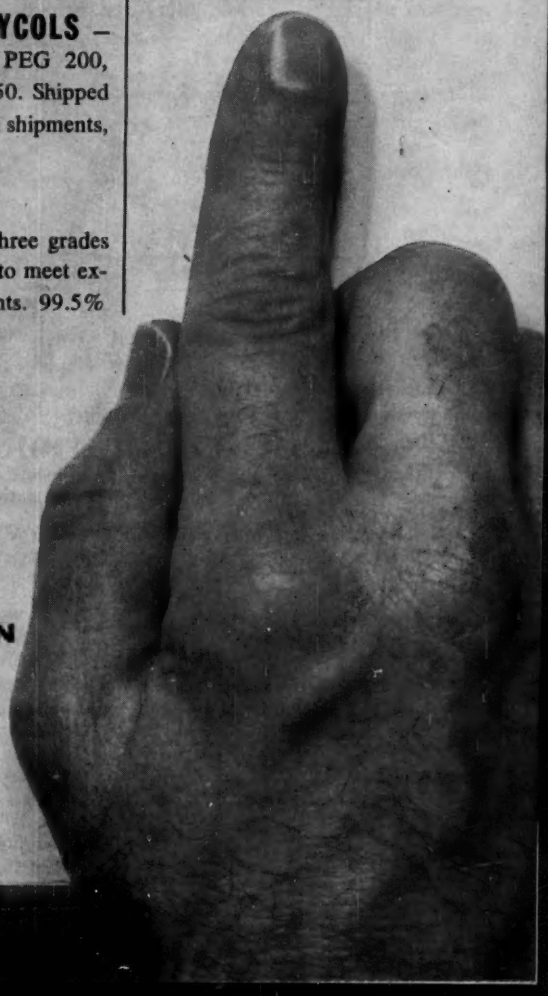

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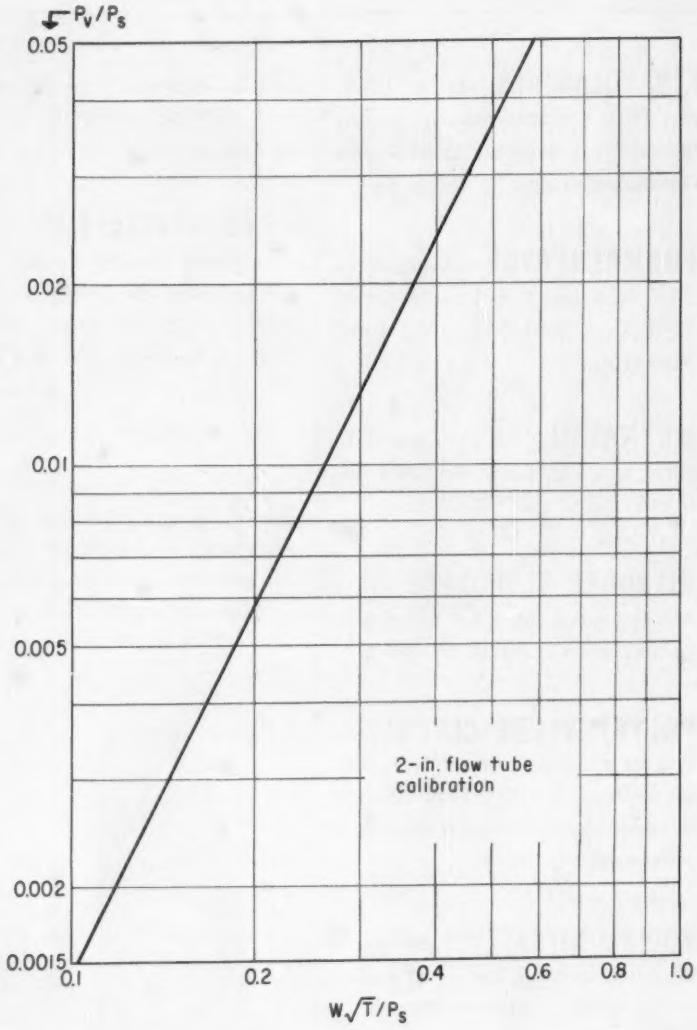

Gas Flow Calibration Correction

Sidney Gross
Research Engineer, Boeing Airplane Co., Seattle Wash.

Frequently it is desired to calibrate piping or other components for mass flow. This is not much of a problem for liquids since density is not strongly affected by either pressure or temperature. For gases, however, the effect of compressibility must be considered, and the applicable formulas are quite different from the equations which one would use in liquid systems.

The brute force approach is sometimes used to calibrate gas flow components such as flow tubes —that is, many measurements of pressure and temperature are taken over a wide range and the results of each run are plotted separately. This not only requires many test points but also presents serious problems in flow prediction at conditions which have not been covered by the tests.

The writer suggests a more useful correlation than those often used. It is based on the relationship:

$$W^2T = CP_sP_v \qquad (1)$$

This equation applies regardless of whether or not there is critical flow in the system under consideration. It is easily derived from the well-known expressions which follow below:

$$P_v/\rho = C_1V^2$$
$$\rho = C_2P_s/T$$
$$W = C_3\rho V$$

where ρ is gas density and C_1, C_2 and C_3 are proportionality constants.

For many applications, Eq. (1) is more convenient in the following form:

$$\frac{W\sqrt{T}}{P_s} = C^{1/2}\left(\frac{P_v}{P_s}\right)^{1/2} \qquad (2)$$

Thus, plotting $W\sqrt{T}/P_s$ vs. P_v/P_s on log-log paper will result in a straight line, and only a few measurements will be needed to establish confidence in the calibration. The curve shown above is characteristic of the results obtained with this method.

In correlating data such as pressure drop across components, a less exact method may be used, substituting ΔP for P_v in Eq. (2). Here, pressure drop data can be correlated by plotting $W\sqrt{T}/P_s$ vs. $\Delta P/P_s$ on log-log paper. Even though this is not exact, it is very useful and accurate enough, particularly if pressure drop is not large—less than about 10% of the total pressure in the system. Note that P_s is defined as the arithmetic average between the upstream and downstream pressures. For convenience in calculation, P_s could be defined as either the upstream or the downstream pressure at a small sacrifice in accuracy.

Nomenclature

C	Proportionality constant.
P_s	Absolute static pressure, psia.
P_v	Velocity pressure, psi.
ΔP	Pressure drop, psi.
T	Absolute temperature, °R.
V	Gas velocity, cu. ft./sec.
W	Gas flow, lb./sec.
ρ	Gas density, lb./cu. ft.
1, 2, 3	Subscripts.

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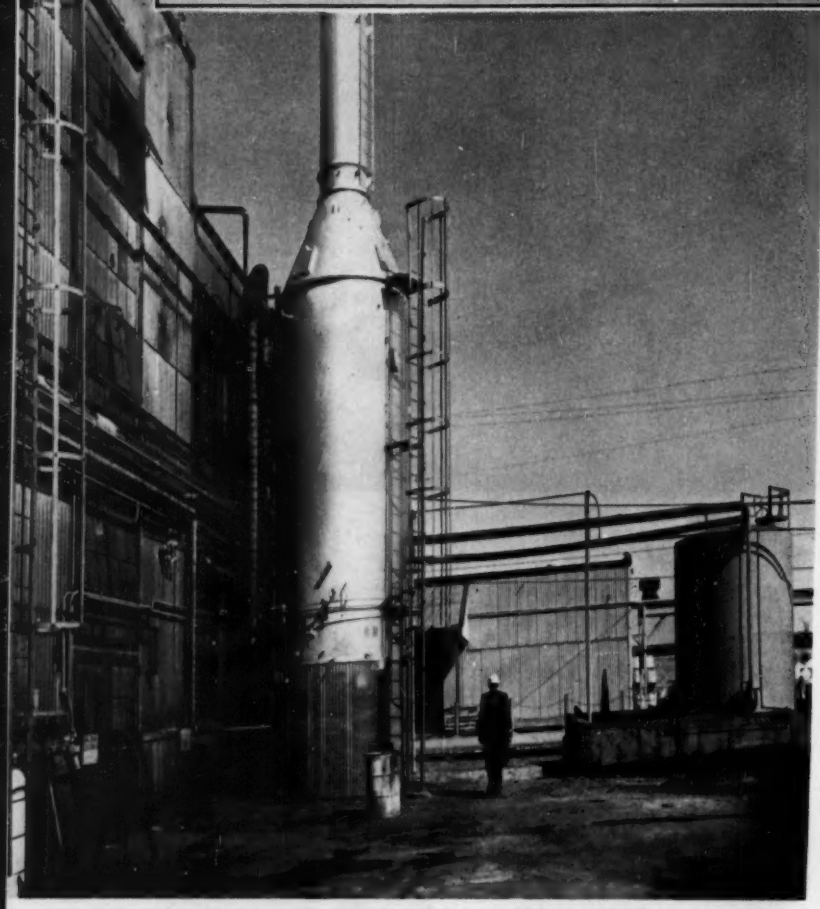

Silicones Solve Problems

Stack stays bright despite long exposure to 1,000 F temperatures and corrosive atmosphere.

B. P. COE, Process Engineer, General Electric Co., Waterford, N. Y.

Silicones have been around for a long time. Most of us are quite familiar with stopcock grease, antifoams, auto polish, O-rings, electrical insulation and Silly Putty, all made from one form or another of this material.

But we are perhaps less familiar with ways that these fairly common materials can help us solve some plant operating and maintenance problems—as superior substitutes for other materials or where other materials just won't do. For instance:

We, at General Electric, had to develop a type of thermal insulation that could be removed frequently and easily and could withstand rough treatment without falling apart. The insulation was required for an odd shaped process vessel that required frequent disassembly and assembly and had to be thoroughly insulated to prevent excess heat loss and fouling of internal surfaces. Operating temperatures went as high as 600 F.

Permanent insulation protected parts of the vessel but this was not practical at flanges and other connection points. We had tried a removable insulation blanketing made of 95% asbestos cloth stuffed with filler material for these special portions of the vessel, but the combination of chemical vapors and frequent rough handling weakened the cloth and caused the blankets to break and wear out every two months. The average cost of replacing a set of ten blankets was approximately $250.

We solved the problem by spraying the insulation blankets with a coating of room temperature vulcanizing silicone rubber, one of the newer members of the silicone rubber family. The coating adhered firmly to the asbestos and markedly improved its mechanical strength and its resistance to chemical attack. Blankets so protected have lasted over a year with no sign of deterioration. Ten dollars expended for material and labor has saved over $1,000 annually.

▶ Try It for Caulking—Another successful application for silicone rubber involved valve boxes for underground piping that have a casing for the underground valve stem in a protective concrete block. In the severe winters of northern New York, seepage of moisture between the pipe and the concrete block was

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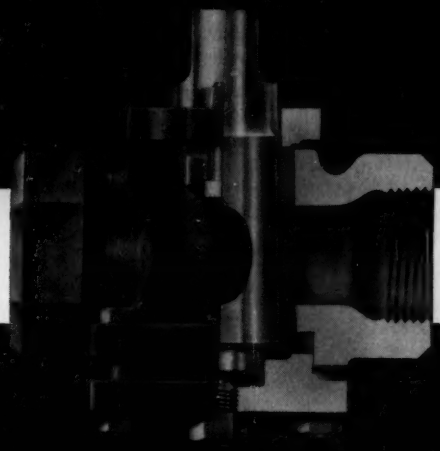

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causing the block to crack. By filling the crack between the pipe and the concrete with liquid silicone rubber and letting it cure, we obtained a neat, flexible and permanent caulking.

▶ **Heat Transfer Media**—Silicone oils are good heat transfer media. They have good thermal and oxidative stability and do not crack or polymerize. Properties silicones have that other heat transfer media lack are almost negligible vapor pressure at high temperatures and much smaller change in viscosity with temperature variation. Low vapor pressure makes silicone oils especially suitable in open tank baths for low pressure heat transfer loops.

We have used a methylphenyl silicone oil for two years in an open temperature calibration bath in our instrument shop. In the pilot plant, silicone oil poured into thermowells eliminates the temperature measurement error that might exist in a dry well. We are considering the same silicone oil for a complete pilot plant heat transfer loop that will operate at temperatures from −20 to 600 F.

▶ **Lubrication** — Standard dimethyl silicone oils are good lubricants for many mechanical systems except for steel to steel sliding lubrication. For systems involving steel to steel contact, there are other silicone fluids and greases with excellent lubricity that can operate at temperatures to 600 F.

Silicone oil works fine as a lubricant for stuffing-box packing. In our plant, packing problems are especially difficult because chlorosilanes leak through the packing to the exterior where they hydrolyze in air to form a siloxane gel and HCl. Packing must be tight and free of lead.

We had a bank of stirred bed reactors that required repacking about once a week with ready cut rings of graphite and asbestos. This packing is normally quite brittle and hard to get in place around the shaft without breaking. But, by soaking the graphite-asbestos rings in silicone oil until the bubbling action stopped, we found that they became pliable enough to permit a neat packing job. The silicone oil also provides a good seal in the voids not filled by packing. Some of our reactors have not required packing in more than a year since applying this new technique.

In other parts of the plant, ordinary braided asbestos has been given this same treatment with identical results.

▶ **Silicone Antifoams**—In one application of antifoams in our plant, we add a small quantity of this material to an emulsion product just before it is placed in drums—reduced foaming during drum filling has cut fill time two thirds.

▶ **High-Temperature Paints** — Our heaters for high-temperature heat transfer liquids and our hot oil heaters are painted with a silicone aluminum paint containing from 25 to 50% silicone vehicle. Under normal operating conditions these coatings last from one to five years at operating temperatures as high as 1,000 F. without discoloration.

During the early stages of high heat exposure, the organic portion of the coating volatilizes while the silicone resin remains intact, firmly anchoring the film to the surface. As the temperature reaches levels above 600 F., and stays there, the resin begins to vaporize slowly—but not until the aluminum is securely fused to the steel substrate.

Another problem we solved with high silicone content paints was color coding of lines operating at 500 F. Unlagged portions such as valves had to be painted with a white that would not deteriorate or discolor.

A silicone heat-resistant white paint provided the color and after two years shows almost no sign of discoloration.

These are only a few of the many places where we have found silicones helpful in our operations. The examples cited may suggest in a rather general way how other chemical engineers might use these materials in solving problems peculiar to their own operations. We are sure that our efforts to date have only scratched the surface.

Benjamin P. Coe received his bachelor's degree in Chemical Engineering from Bowdoin College and M.I.T. in 1953. Since graduation, he has worked for General Electric, graduating from G.E.'s Advanced Technology Course in 1955 and joining the Silicone Products Dept. as a process engineer.

Mr. Coe is a member of the AIChE and editor of the *AIChE News* for the Northeastern New York Section.

Can Maintenance Infringe Patents?

Can you infringe a patent when you repair a machine that you own? Like so many other things, that depends.

To paraphrase Bryce Beecher of the General Motors Patent Section, the purchaser of a patented machine is permitted to make reasonable repairs. However, unless expressly agreed to, the owner does not have the right to reconstruct the machine. So the question boils down to what is repair and what is reconstruction.

It would seem that simple repair merely puts the machine back in its original state with no change whatever. But, says Mr. Beecher, writing in a recent issue of the *General Motors Engineering Journal*, if you use parts similar to those in the original machine but from a different manufacturer you might infringe the patent, even though you have made no change in the design, function, shape or capacity of the original machine. Then again, substitution of a part may not infringe the patent.

In other cases, significant alteration of a machine or apparatus that increases its capacity or improves its design might infringe the patent.

The only thing Mr. Beecher's article proves to us is that patent law is far beyond the average layman. In case of doubt, or even when you are sure that you are right, see your lawyer.

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Our picture shows an asphalt tank skyrocketing after the bottom-to-shell seam failed during a fire at Perth Amboy, N. J., in 1949. Two firemen were killed.

Had this tank been designed properly with a deliberately weakened head-to-shell seam, the head would have lifted under excessive internal pressure and it is possible that the contents would not have caught fire at all.

Such incidents, unfortunately, are not rare. The National Fire Protection Association can cite many vessel failures that are directly attributable to improperly designed vessels, as in the case above, or improperly vented vessels.

For example: On July 19, 1956, nineteen firemen were killed near Dumas, Tex., when a spheroid-type tank suddenly ruptured, releasing a huge ball of burning liquid. Burning vapors from the tank vent had impinged on the tank shell, softened the metal and caused the vessel to rupture.

▶ **Function of Emergency Vents** —Emergency vents are required on all above ground vessels containing flammable liquids to prevent overpressure when the tank is exposed to fire or internal uncontrolled chemical reactions.

Unfortunately, the only vents provided on many low-pressure vessels are those for normal breathing. Even these are often inadequate for their purpose—many tanks have collapsed or bulged because the vents were poorly designed or maintained.

▶ **Influence of Tank Design**—If a tank were designed to fail at less than 0.5 psi., there is no need for emergency vents as it is unlikely that pressures will build up to dangerous levels. Such tanks would include the familiar cone roof tank, atmospheric tanks more than 36 ft. in diameter, floating roof tanks and lifter roof tanks. These have, or should have, a weak roof-to-shell joint so that the roof will lift or tear loose first under excessive internal pressure or explosion. They do not need emergency relief vents, but the fixed roof types do require breathing vents.

Low pressure tanks are those designed to withstand pressures greater than 0.5 psi., but not more than 15 psi. Most common of these are the conventional horizontal tanks, but the category also includes vertical tanks not equipped with a weak roof-to-shell joint, certain spheroid tanks and others that do not class as pressure vessels.

Pressure vessels are those designed to withstand more than 15 psi. However, even these may be classed as atmospheric tanks if equipped with vents that would prevent the pressure from rising above 0.5 psi.

▶ **Design of Vents**—There are two major factors to consider when selecting emergency vents: select the limiting pressure at which the tank will operate, taking into account the design pressure of the vessel; and secure an emergency vent with a relief capacity as required for the size of tank and pressure at which it operates.

Vent size refers to the approximate diameter in inches of an unobstructed circular opening. The only time you would have such an unobstructed circular opening would be where a 12 in. or shorter straight open pipe is used with no venting device at its end. Addition of any device (such as relief valve, pressure-vacuum vent or flame arrester) to the end of the vent pipe will restrict the vapor flow and necessitate a larger pipe size.

As important as vent size is vent design to prevent impingement of flame on the vessel shell which can lead to the disasters mentioned earlier. Weather hoods and relief line drains are frequent offenders in this regard.

▶ **Other Considerations** — Unprotected steel tank supports often fail under exposure to fire and permit the tank to drop to the ground before sufficient pressure builds up to overpressure the tank. In some cases this sudden collapse has broken open the vessel and in others only the piping was broken off. In either event, the tank contents were added to the fire with disastrous consequences. Therefore, supporting steel for flammable liquid tanks must be protected by materials that will give at least two hours' fire resistance.

Still other considerations would be heat-actuated valves at tank outlets, slope of the ground, dikes, and the like.

ACKNOWLEDGMENT

This item is an abstract of a paper entitled "Inadequate Vents on Flammable Liquid Tanks" by Miles E. Woodworth, NFPA flammable liquids engineer. It was originally published in the Jan., 1960 issue of the *NFPA Quarterly* and is abstracted here with the permission of the National Fire Protection Association, Boston, Mass. Reprints of the original article are available from NFPA.

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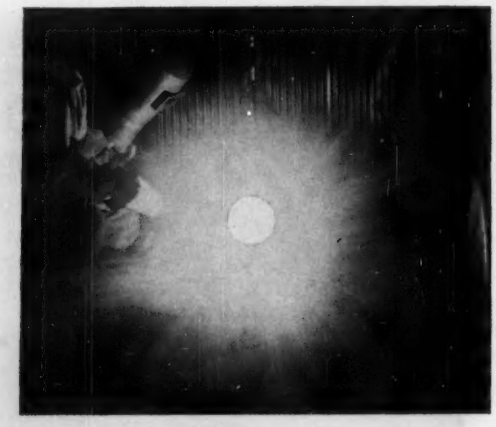

New "Super-Weldable" Stainless Coming

Unique, newly developed 16 Cr-20 Ni steels, low in silicon and carbon—which resist cracking during welding—will be available soon.

A new family of stainless steels that resists cracking under welding heat and stress is in the offing.

F. C. Hull, advisory metallurgist at the Westinghouse research laboratories in Pittsburgh, Pa., outlined the requirements for what he calls "super-weldable" stainless steels at the recent 63rd annual meeting of the ASTM in Atlantic City, N. J. These requirements are based on a study of how 18 alloying agents affect "hot cracking" of 16 Cr-20 Ni stainless.*

Westinghouse is calling the new steels Kromarc. The program is still in the research and development stage, although several one-ton pilot heats have been made by Westinghouse and used to fabricate welding rods and laboratory vacuum systems.

* Study was limited to effect of alloying agents on cracking during metal solidification (weld metal, cast parts).

Patents are pending on the new compositions, and when they are granted, Westinghouse will probably work out license agreements with various steel companies.

▶ **Alloy Guideposts**—No hard and fast specifications are possible, but a number of guideposts for amounts of alloying agents come out of this work, in which some 100 different alloys were tested—all centering around a basic 16 Cr-20 Ni austenitic steel.

For instance, when cobalt is added to the base composition, there is no appreciable change in hot cracking. This is true for 0, 1 and 4% cobalt levels. Carbon, on the other hand, increases cracking, while nitrogen appears to be beneficial.

Substantial amounts of manganese (up to 7%) decrease susceptibility to hot cracking and up to 3% silicon increases it. Copper also causes cracking.

Two stabilizing elements frequently found in high-strength, high-temperature stainless steels are very effective in promoting hot cracking. These are titanium and columbium.

In AISI 321 and 347 steels, both elements are added as carbide stabilizers to prevent intergranular corrosion.

▶ **Tantalum Better**—But from a

Alloy "Blueprint" for Crack-Resistant Cr-Ni Steels

N	Decreases weld-cracking susceptibility
Mo	Decreases cracking (minimum cracking at 3% Mo)
Mn	Decreases cracking (up to at least 7% Mn)
W	Decreases cracking (up to 5% W studied)
Co	Little effect
V	Little effect
Al	Increases cracking very slightly up to 0.2%, more rapidly at higher levels.
Ta	Mildly detrimental in causing weld cracking (up to 3% studied)
Cu	Increases hot cracking (up to 2% Cu studied)
Si	Small amounts increase hot cracking (up to 3% studied)
Cb	Causes severe cracking up to 1.25% concentrations
Ti	Causes severe cracking (up to 0.9% Ti studied)
C	Keep as low as possible
Zr	Extensive cracking in concentrations of 0.4%
B	Extensive cracking in concentrations of 0.05%

Stress-Corrosion Cracking a Problem?

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hot cracking standpoint, tantalum-stabilized stainless is a much better choice, since this element does not increase cracking nearly as much as Ti and Cb. However, tantalum is expensive, and can't be used in certain nuclear steels, since it has a high affinity for neutrons. Also, there seems to be a high loss of tantalum during melting and welding, from the base alloy.

Other bad actors, according to the Westinghouse study, include boron and zirconium. Many stainless steels and high-temperature alloys are currently being produced with additions of boron and zirconium to increase strength, creep ductility and hot workability. Both produce extensive surface cracking—passing through a maximum at 0.05% boron and 0.4% zirconium. These maximum points are a little misleading, however, since tested specimens with larger amounts of either boron or zirconium have extensive internal cracks.

▶**Helpful Elements**—On the helpful side, vanadium up to 5% has little effect and may be slightly beneficial; it can, therefore, be safely added as a solid-solution strengthener or as a scavenger. Tungsten and molybdenum, very effective agents for increasing creep strength, actually decrease susceptibility to hot cracking when added in amounts up to 5% and 3% respectively.

▶**Steel Blueprint**—Based on these results, Dr. Hull has worked up a blueprint for stainless steels that resist hot cracking.

In the base composition, chromium should be as high as possible, while nickel should be as low as the composition permits. Carbon should be low, but nitrogen can be relatively high.

Manganese should be much higher than normally used in chromium-nickel steels, probably a minimum of around 7%. Aluminum is permissible in small amounts (up to 0.2%) but silicon should be as low as possible.

Higher strengths can be obtained by adding vanadium, tungsten and molybdenum. For carbide stabilization, preferred addition is tantalum, not titanium or columbium.

Based on equal weight percentages, the elements studied can be ranked in order of increasing tendency to hot cracking as follows: N, Mo, Mn, W, Cr, Co, V, Al, Ni, Ta, Cu, Si, Cb, Ti, C, Hf, Zr and B.

▶**Pin Tear**—In conducting the research program, samples were evaluated with a low-cost laboratory technique called the cast pin tear (CPT) test. This involves observing cracks in chill-cast pins as they solidify under restraints similar to welding of thick steel sections.

Such a test, of course, has to be correlated with actual cracking in welds. The Westinghouse study didn't involve welding of samples. But there seems to be ample reported welding data which indicate a strong correlation between test results and field experience, according to Dr. Hull.

Cures for Salt-Water Cooling Woes

Planning to use salt-water cooling? Corrosion will be much more troublesome than with fresh-water systems.

As fresh water becomes more of a scarcity item, many chemical plants and refineries are turning to salt water for cooling purposes. But practically all these plants—in this country and overseas—have, in due course, run up against major corrosion problems.

Much of the trouble comes from trying to apply fresh-water practice to salt water. Since salt water is a superior electrolyte, many fresh-water materials of construction simply can't stand up.

Most plants use the "once-through" design (a few refineries recycle salt water through cooling towers). And a major trouble spot is the water-distribution system—pumps, valves, piping that carry cold water to a condenser or cooler and remove it at a higher temperature.

Actually, most salt-water problems can be overcome by proper choice of materials and design.

The table shows an idealized conception of a well-designed cooling system for a petroleum refinery (see p. 166).

For salt water, corrosion control starts with good hydraulics. First essentials: pipe water velocity below 7 ft./sec.; smooth flow; low-speed pumps with drowned suction; exclusion of debris and marine growth with screens.

▶**Line Pipe** — When cooling-water intake lines are steel or cast-iron pipe, a combination of thick coatings based on coal-tar pitch plus cathodic protection is effective.*

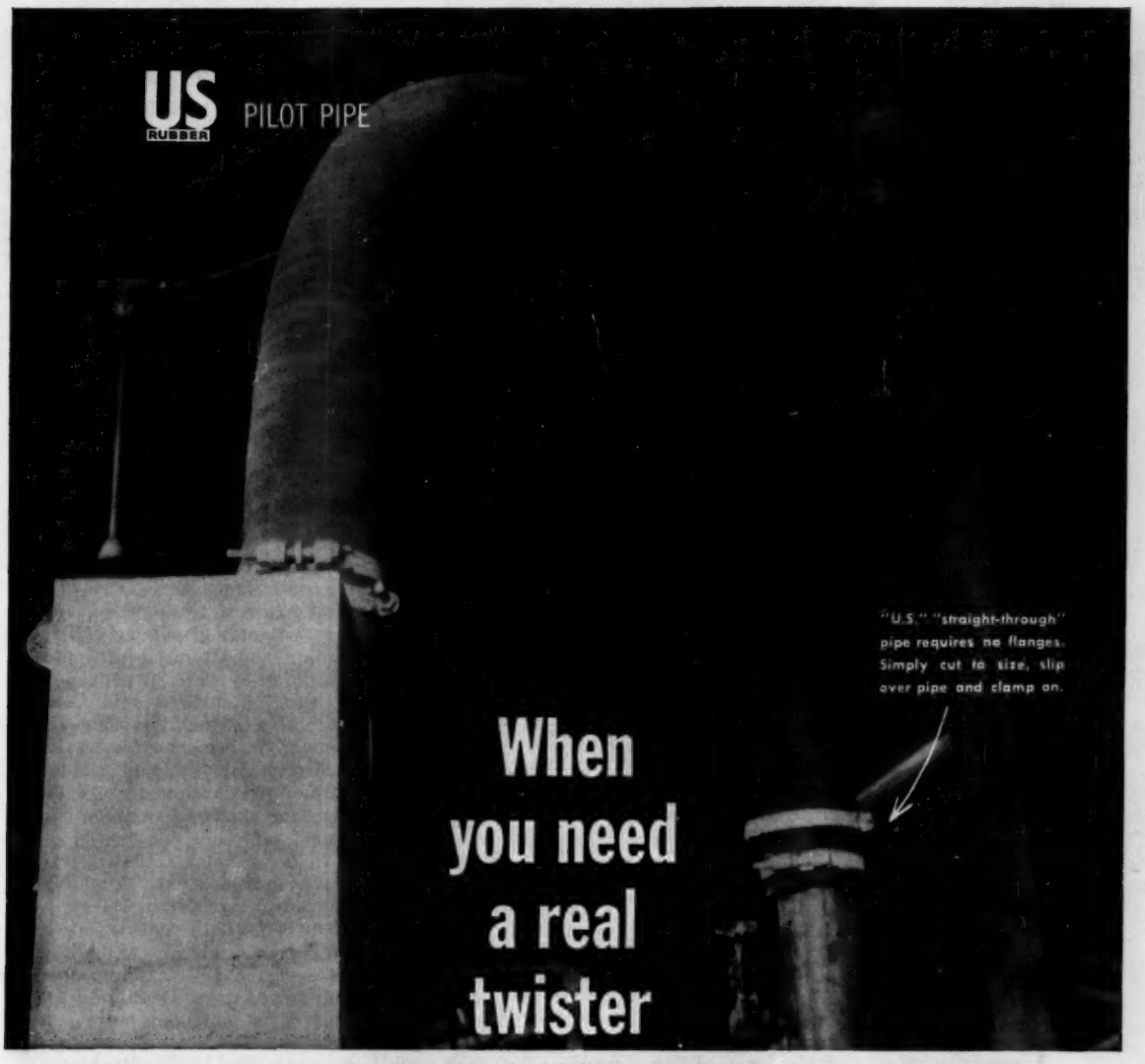
Mechanical fine screens are often an undesirable mixture of metals — structural-steel frame work; stainless, Monel or bronze screens; galvanized linkage between screens; cast-iron rollers. Cathodic protection is useful here and nylon rollers should be superior to cast iron.

For circulating pumps, good design is vital. The 18-8 stainless steels have excellent cavitation resistance, while the usual pump materials, bronze impellers and cast-iron casings, have poor resistance. Proper pump design can usually avoid cavitation problems, however.

But cast-iron casings are also subject to graphitization (metallic iron is removed, leaving a layer of graphite). There's been some success in lining graphitized cast iron with neoprene. However, proper surface preparation (including graphite removal) is critical.

▶**Main Lines**—For cold-water

* For application of reinforced-concrete pipe, see *Chem. Eng.* Aug. 1957, p. 300.


US RUBBER
PILOT PIPE
"U.S." "straight-through" pipe requires no flanges. Simply cut to size, slip over pipe and clamp on.
When you need a real twister

...Get U.S. Pilot Pipe!

This limber, highly abrasive-resistant U. S. Pilot® Pipe is at work 7 days a week, 24 hours a day (during the 6-month concentrating season) in the heavy media department of the beneficiation plant of a large iron ore producer. It carries 200 gallons per minute of ferro silicon into a magnetic separator.

BIG REASONS WHY U. S. PILOT PIPE IS USED:

- Company records show that U. S. Pilot Pipe lasts about 12 times longer than metal pipe.
- Maintenance is nil.
- Pilot Pipe is so flexible it permits an easily formed angle, eliminating need for elbows (the smooth flow reduces points of turbulence) hence it takes up less room, requires less plumbing.

U. S. Pilot Pipe includes a wide range of designs ("straight-through", duck and rubber flanges, swivel flanges) that handle a wide range of working pressures—from 25 to 250 pounds—and also handle a wide range of chemicals and abrasives.

• • •

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Elements of a Well Protected Salt-Water Cooling System for Process Plants

Intake Pipe	Steel pipe, blast cleaned and coated with epoxy-pitch before installation. Cathodic protection by impressed current.
Pumps	Drowned suction. Cast-iron casing and bronze impeller, with internal cathodic protection by impressed current.
Main Pipes	Fabricated from steel plate, blast cleaned or acid descaled. Concrete lined on the site. Water velocity limited and local turbulence avoided.
Main Valves	Cast iron for cost reasons. Design for simplicity as well as efficient closing (butterfly instead of wedged gate). Protect by coatings and sacrificial anodes.
Unit Pipework	Usually steel, factory lined with cement mortar, epoxy-mastic or epoxy-pitch. Join with welded sleeves. Nonferrous pipe below 4-in. dia.
Condenser Ends	Cast steel, blast cleaned, lined with epoxy-mastic and fitted with sacrificial anodes. Generous depth of floating head cover. Restricted water velocity.

mains, a number of linings have proved useful:

- Bituminous enamels, factory or site applied.
- Thin concrete or reinforced thick concrete, site applied.
- Thin, spun concrete, factory applied.
- Sheet rubber, site applied.
- Heavy-film neoprene paint, factory applied.

Coatings and linings are, of course, dependent on adhesion to the steel base.

Concrete is more suitable for buried mains, which do not undergo rapid temperature changes.

The size of main valves makes cast iron the economic material, with nonferrous trim. Cathodic protection with a zinc-alloy anode and a high-quality coating is a good idea, but requires a simple valve to be effective.

▶ **Unit Piping** — Pipe on or around heat exchanger units must retain structural stability under emergency high-temperature conditions. Thus, cast iron, asbestos-cement and plastic pipe are not favored in refineries for this service. Choice is restricted to steel or nonferrous metals.

With relatively high temperatures, the pipe needs an internal coating. One interesting development is concrete-lined pipe, joined at the site with a filled epoxy mortar and metal sleeve.

For pipe too small for lining (below 4-in.) 5% cupronickel with 1% iron is on trial. Aluminum-brass has been useful in this service.

For unit-piping valves, usual choice is a wedge gate, but diaphragm designs, with cast-steel bodies are very promising, particularly for throttling service.

▶ **Exchanger Ends**—Impressed-current cathodic protection is used on channel ends of condensers and coolers in some plants. But possible spark hazards have forced others to go to sacrificial anodes.

For ferrous channels, it's good practice to face the channel flange and division-plate edge mating with the tube plate with two layers of Mo-bearing austenitic stainless. All wetted channel surfaces should be blast cleaned, then coated with epoxy-mastic. Zinc anodes can be welded onto the channel cover. It's important not to use sacrificial anodes that produce voluminous corrosion products (they will block condenser tubes). Tube ends and plate need a coating with epoxy or epoxy-phenolic paint.

On floating-head ends, a deep head cover permits a sufficient weight of sacrificial anodes and also minimizes turbulence. Lined or nonferrous covers are not an answer unless sacrificial anodes are fitted to protect tube ends.

Condensed from a paper by E. D. Dolan, British Petroleum Co., Ltd., given at a symposium on corrosion in the petroleum industry in London, England, under the sponsorship of the Society of the Chemical Industry and the Institute of Petroleum. Symposium papers will be published soon as a book by Macmillan in this country.

Corrosion Tests Confirm Ti-Pd Alloy Superiority

The excellent corrosion resistance of titanium-0.2% palladium alloy (*Chem. Eng.*, May 18, 1959, p. 200) has been confirmed by recent tests in reducing environments.

At Argonne National Laboratory, samples of commercial titanium and titanium-0.2% palladium alloy were suspended in boiling 5% sulfuric acid. Commercial titanium was removed after 85 hr. because of excessive corrosion, but tests on titanium-palladium continued for 170 days and showed a very low corrosion rate.

In tests under actual operating conditions at Columbia-Southern, Barberton, O., specimens of both metals were placed in a stream of boiling, non-aerated 73% calcium chloride for 84 days. Titanium-0.2% palladium samples were unaffected, while the unalloyed titanium was badly pitted.

All-Aluminum Barge Big Metal Market?

An all-aluminum barge will be built soon for Industrial Marine Service, Memphis, Tenn. According to its developer, Reynolds Metals, this will be the first large barge ever built from aluminum.

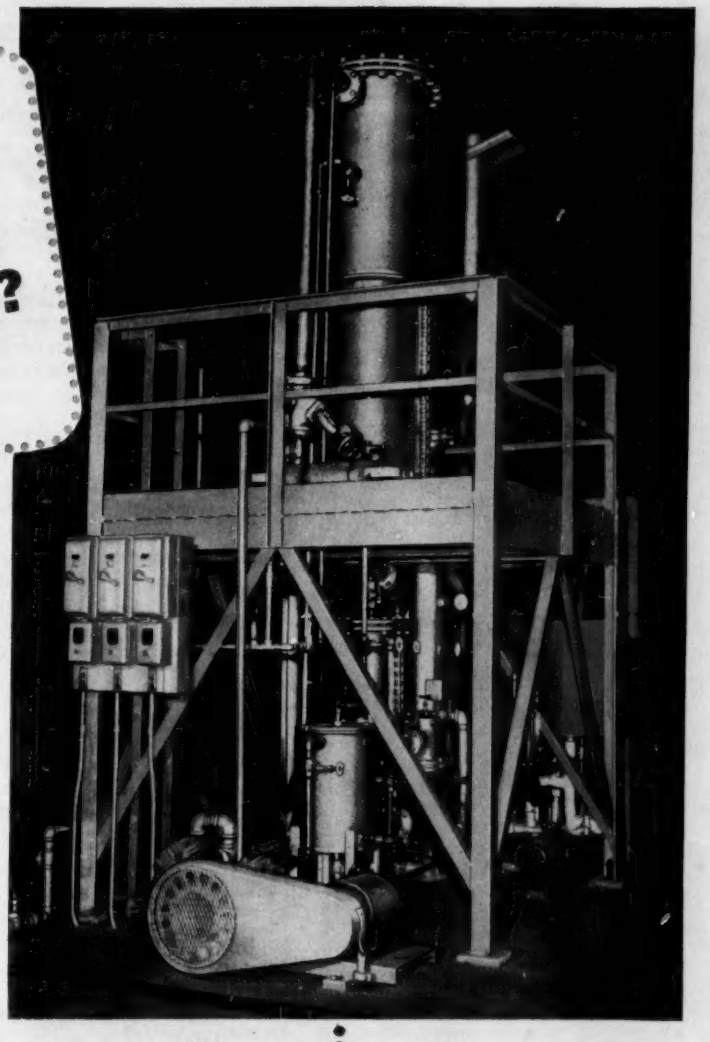
It will have a capacity of 5,200 bbl. (97½-ft. long by 35-ft. wide) and will carry Diamond-Alkali-made perchloroethylene between Houston, Tex., and Pittsburgh, Pa., on the Mississippi-Ohio river system.

The barge will have a 10 to 20% larger payload than a similar steel vessel.

HEAT TRANSFER PROBLEMS?

CB&I

Pilot Plant Facilities and experience can help you find the best solution



CB&I pilot plant facilities are available for determining heat transfer coefficients on unknown materials. Typical evaporator-crystallizer unit at right provides valuable data for design of processing equipment.

In the design of heat transfer units, such as multiple effect evaporators and crystallizers, there is no substitute for experience and equipment. This is why so many *companies with heat transfer problems* bring them to CB&I.

Here, CB&I's expert chemical engineering staff—using pilot plant facilities—tackles each problem on an individual basis. The result: custom-designed heat transfer equipment to meet specific requirements.

It will pay you to investigate CB&I's *coordinated services*—engineering, fabrication and erection—which form a single source and responsibility for *guaranteed* heat transfer equipment. Write today for details.

CB&I Engineered Equipment Includes:

- Crystallizers
- Evaporators
- Flash Evaporation Systems
- Condensers
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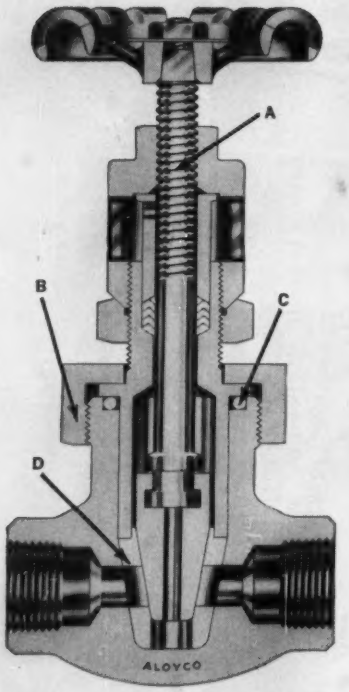
Aloyco Plug Gate Valve #66 succeeds with severe corrosives for 10 straight years!



Shown ⅔ actual size of the half-inch valve

WHY? **A. OUTSIDE STEM THREADS** are away from corrosive area, prevent galling.
B. UNION BONNET provides extra strength and easy disassembly.
C. O-RING made of "Teflon"* provides tough, leak-proof seal.
D. SEATS made of "Teflon"* are pressure-tight, dependable, won't gall. Renewable.
STAINLESS STEEL: 18-8S, 18-8SMo, Aloyco 20.

FOR: Instrument lines, small lines handling viscous fluids, or where low pressure drop is important.

FACTS: full-floating plug disc exerts no twisting action on the removable seat in closing. Aloyco Stainless Steel #66 Plug Gate Valve: 1200 lb. at 150 F.; 600 lb. at 500 F. Sizes: ⅛", ¼", ⅜", ½". Want more? Write: Alloy Steel Products Company, 1301 West Elizabeth Ave., Linden, New Jersey. O-5

*Registered DuPont Trademark

Longer Lasting ALOYCO VALVES
1ST IN CORROSIVE SERVICE

ALLOY STEEL PRODUCTS COMPANY

(*Continued from p. 64*)

lene plant at Orange, Tex. Plant will increase Allied's output of low-molecular-weight polyethylene by roughly 50%.

The Anaconda Co. is undertaking a $6-million replacement and modernization program to improve copper refining, other operations at its smelter in Anaconda, Mont. Program is to be completed in 1961. One of its main aims is to modernize the plant's roaster and reverberatory furnace systems. The company will install two modern fluid-bed roasters to replace 12 roasters of older design, and it will improve the feed system for reverberatory furnaces by replacing trams with conveyor belts and by providing for mixing of wet and dry feed.

Celanese Corp. of America will expand facilities for producing higher acrylate esters at its plant in Pampa, Tex. The multimillion-dollar project, due for completion by the end of this year, will double the plant's over-all acrylate capacity. The expansion will include facilities for making glacial acrylic acid, 2-ethylhexyl acrylate and butyl acrylate.

Allied Chemical Corp.'s General Chemical Div. is building a large new plant at Elizabeth, N. J., to produce the firm's Genetron line of fluorinated hydrocarbon refrigerants and aerosol propellants. Scheduled for completion early next year, the plant is going up at Allied's Elizabeth Works where the company now makes sulfuric acid. It will be Allied's third Genetron facility; the other two are at Baton Rouge, La., and Danville, Ill.

California Spray-Chemical Corp. announces that it will build a $22-million chemical fertilizer plant at Ft. Madison, Iowa. According to current plans, the new facility will produce 300 tons/day anhydrous ammonia, 150 tons/day prilled ammonium nitrate and 600 tons/day complex fertilizers. (See p. 106 for a description of Calspray's ammonium nitrate and complex fertilizer processes.)

Mobil Chemical Co., newest operating division of Socony Mobil Oil Co., Inc., announces that it is building the world's largest ethylene unit at Beaumont, Tex. The new facility, seen taking shape above, is scheduled for completion early next year. It will supply petrochemicals to neighboring plants of Houston Chemical and Goodyear Tire & Rubber.

Menasha Wooden Ware Corp.'s pulp and paper division is building a multimillion-dollar pulp and paper mill at North Bend, Ore. Project includes a semichemical neutral sulfite-pulp mill, a corrugating-medium paper mill and auxiliary facilities. Engineering and construction are being handled by The Rust Engineering Co., Pittsburgh, Pa., and the facilities are expected to be on stream next summer.

Pennsalt Chemicals Corp. has awarded Catalytic Construction Co. of Philadelphia a contract to build a $1.5-million alkyl alkanol amines plant. Site will be at Pennsalt's Wyandotte, Mich., works. The plant, scheduled for completion late this year, will use an improved, completely continuous process developed by Pennsalt.

American Potash & Chemical Corp. announces plans for a 10-million-lb./yr. electrolytic

manganese plant at Aberdeen, Miss. Construction for the $5-million project is due to start this fall, and to be completed late next year. American Potash & Chemical is locating the plant next to its existing sodium chlorate facilities at Aberdeen.

Jefferson Lake Petrochemicals of Canada, Ltd., subsidiary of Jefferson Lake Sulphur Co., Inc., New Orleans, proposes to build a gas gathering system and processing plant to serve the Calgary gas field. Company has applied for authorization from the Alberta conservation board, plans to have the facilities installed next year. Plant is to handle 150 million cu. ft. of raw gas daily, its cost is estimated at close to $12 million.

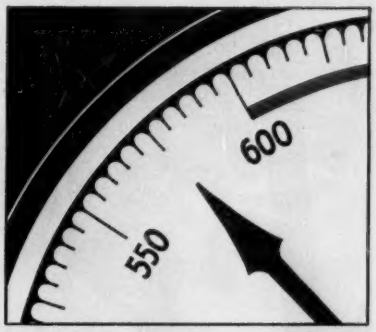
Kaiser Aluminum & Chemical Corp. is building a plant at Gary, Ind., which it will use mainly for calcining byproduct petroleum coke from oil refining. Company will make carbon electrodes from the coke, for reduction cells in its primary aluminum plants. Feed capacity will be 120,000 tons coke per year. The facility will cost about $1 million, is slated to go on stream this fall.

Suntide Refining Co., subsidiary of Sunray Mid-Continent Oil Co., is building a 60-million-lb./yr. styrene unit at its plant in Corpus Christi, Tex. Entire output of the forthcoming unit has been sold under favorable long-term contracts, Sunray reports. Construction is scheduled to start around Nov. 1, and the unit is to be on stream in the spring of 1962.

Consolidated Mining & Smelting Co. will install a liquid-chlorine and caustic soda plant at Trail, B. C., Canada. Construction of the $2.6-million facility will be by J. T. Donald & Co., Montreal. The facility's output will be used at a kraft pulp mill that Celgar Ltd. is currently erecting at Castlegar, B. C.

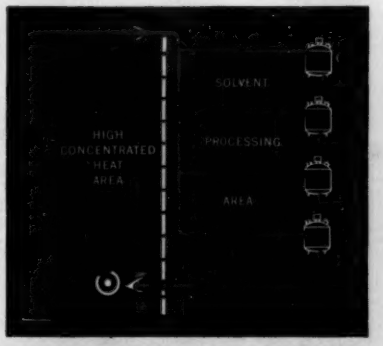
Firestone Tire & Rubber Co. is constructing a semiworks polypropylene unit at Orange,

AROCLOR SYSTEMS DELIVER STEADY PROCESS HEAT TO 600°F and...



PINPOINT HEAT CONTROL...

to within 2° F. Indirect heating with Aroclor 1248 ends processing problems from local hot spots and overheating. Units range from small, portable electric types to large, gas- and oil-fired heaters generating up to 20,000,000 BTU's per hour. Typical uses: cooking of alkyd resins, dyestuff synthesis and other chemical reactions, deep-fat frying and other food processing, drying ovens and molding equipment.



ECONOMY! Unpressurized systems cost less to install and maintain than pressurized systems. Forced circulation of liquid Aroclor requires no condensers, vaporizers, traps, heavy-walled jackets or complex feed mechanisms. Compact design saves space. Heat from a single unit can be supplied for multiple uses at different temperatures. Total efficiency saves processing dollars.

FIRE SAFETY! Even a blowtorch won't ignite fire-safe Aroclor 1248. A heating system designed with Aroclor 1248 eliminates the hazard of the vaporized, flammable fluid or danger of direct flame processing. Operating in a closed system vented to the atmosphere, these heating systems also eliminate the threat of "live" steam or chemical vapors escaping under pressure.

Write or use coupon for guide to selecting the best system for your application.

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Please send information booklet on Aroclor 1248 heating systems and guide to heater selection.

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Take a Fresh Look at **SUPER POWERHOUSE**
Insulating—Finishing Cement

You readily see there is an improved whiteness—Super Powerhouse dries *super* white. It withstands rain, sleet and snow after initial set—no redoing jobs because the weatherman erred. It has outstanding coverage, insulates and finishes in one coat yet performs better than many insulating cements.

New advantages such as these make it imperative to check your insulation specifications before rewriting them for a new project. Baldwin-Ehret-Hill offers you the complete line—a selection of over thirty different specialized insulation products for service from sub-zero to 1900 F. Each is designed to give you greater efficiency, easier application and lower installed cost. To bring your specifications up to date, write for our new 1960 catalog or see it in your Sweet's file.

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THE COMPLETE LINE OF INSULATIONS for use SUB-ZERO TO 1900 F.

CONTRACT APPLICATION SERVICE FROM COAST TO COAST

Tex. It is expected to be in operation early next year.

Allied Chemical Corp. announces that its Solvay Process Div. will build a plant to produce polyethers at Baton Rouge, La. Initial capacity will be about 20 million lb./yr., and the unit is due to go on stream by June, 1961. Its starting material will be propylene oxide. The polyethers will be marketed by Allied's National Aniline Div.; they are used in making rigid and flexible urethane foams. (Allied already produces and markets isocyanates, the prime ingredients for urethane foam manufacture.)

British American Oil Co., Ltd., will add an aromatics extraction plant to its Montreal East refinery in Canada. The unit will cost over $2.5 million, and construction is scheduled to begin this fall. Company hopes to have the plant on stream before July, 1961. It will use the Udex process developed jointly by Universal Oil Products and Dow Chemical. A prime product will be benzene, which is required for the cumene operation at the nearby B.A.-Shawinigan petrochemical plant, in which cumene is converted to phenol and acetone. The extraction unit will be designed so that it can later produce other aromatics in addition to benzene.

Texaco Canada Ltd. is also building an aromatics plant. It will be at Port Credit, Ont., and will produce benzene and toluene. Cost is estimated at over $2 million. Expected to start production in 1961, the unit will include a low-pressure catalytic reformer, a Udex extraction unit, and storage, loading and other facilities. Initial throughput will be 1,500 bbl./day. Provision is being made for future production of other aromatics.

Diamond Alkali Co. has announced that it is beginning a long-range expansion program for its chlorinated products plant at Belle, W. Va. Over-all

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Temperature difference control within ½ of 0.1°C — that's what American Cyanamid demands for process evaporators at their Organic Chemicals Plant in Bound Brook, New Jersey. Boiling-point rise must be held at 108.5°C, since even slight variations affect product quality.

A Foxboro Dynalog Recorder-Controller, with full-scale span of only 5°C, provides the close control American Cyanamid requires. Control is held continuously within 1/20th of a degree of set point — with chart records for proof.

Cyanamid's Narrow Span Controller was installed in 1955. It's been running continuously ever since, virtually unattended. The only servicing or maintenance required on the Dynalog has been re-inking and chart changing.

Get the complete story on the exclusive Dynalog Controller, with full-scale spans as narrow as 5°F — the narrowest span available to industry today! Write for Bulletin 20-10. **The Foxboro Company, 368 Neponset Ave., Foxboro, Mass.** **Reg. U. S. Pat. Off.*

FOXBORO
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DYNALOG ELECTRONIC INSTRUMENTS

cost will probably be about $1 million.

Hooker Chemical Corp., New York, has acquired Butler Chemical Co., of Galena Park, Tex., a manufacturer of defluorinated phosphate rock. The latter company, formerly a division of Houston Corp., Houston, will operate for the present as a separate Hooker unit under the Butler Chemical name. Its product is used as a supplement for animal and poultry feed.

Syntex Laboratories, Inc., has been formed by Syntex Corp. to manufacture and market, under its own label, steroid specialty products in the U. S. Up to now, products under the Syntex label have been available only in Mexico and other Latin-American countries.

Allis-Chalmers Mfg. Co. has acquired 50% of the common stock of Consolidated Systems Corp., Monrovia, Calif. Consolidated Systems has been a wholly-owned subsidiary of Bell & Howell's Consolidated Electrodynamics Corp.; it has specialized in development of systems-engineering.

OVERSEAS BRIEFS

Greece: A contract has been awarded to Chemical Construction (G.B.) Ltd., England, for what will be Greece's largest single-unit sulfuric acid plant. It will be built for the Greek Ministries of Industry and Coordination, as part of a large nitrogenous fertilizer

now Liquid or GAS
OXYGEN and NITROGEN
simultaneously

FLEXIBILITY of operation, providing ANY COMBINATION of products, liquid or high pressure gas PLUS simultaneous production of BOTH oxygen and nitrogen delivers maximum yield of combined products at minimum cost of operation with little operator's attention. Packaged design requires minimum of installation cost and space.

This most modern and efficient design from Independent combines the best features of the earlier two-product package plants pioneered by Independent with the latest concepts of external refrigeration. Type illustrated in 1500 to 5500 cu. ft. per hour capacities. Other types in larger and smaller sizes. Pure argon available on larger sizes.

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CYLINDERS AND GAS PRODUCING EQUIPMENT
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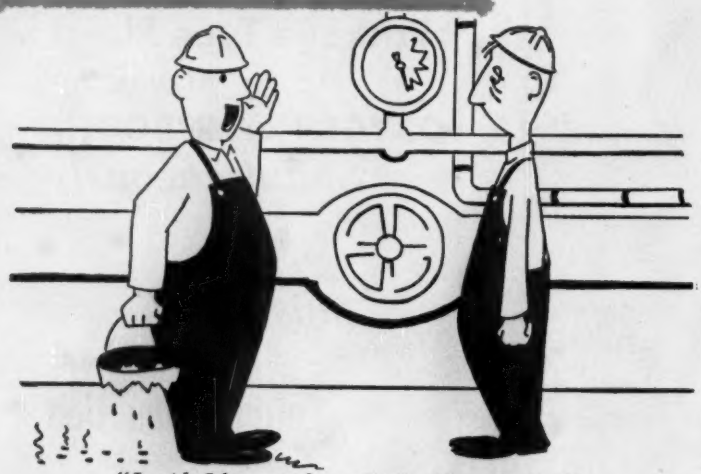
Life in these excited states...



"I said, I borrowed a pail of acid... O. K.?"

High-impact, rubber-plastic, most economical for average chemicals. ½ to 6". Screw or solvent welded fittings. Valves ½ to 2". NSF-approved. *Bul. 80A.*

Time Can't Be Borrowed Either

Equipment running on borrowed time due to corrosion has a knack of dropping the bottom out of production when you can least afford it. No need to risk it... just specify Ace chemical resistant equipment. Best for the money anywhere... backed by 108 years' experience.

Rubber or plastic lining is economical life insurance for costly "special" equipment. It's a specialty with ACE. Write for *Bul. CE-53.*

Choice of Rivi-clor PVC, Ace-Ite rubber-plastic, Ace polyethylene or Ace Saran to match *any* plastic pipe. Sizes ½ to 2". Also larger plastic-lined valves.

Ace-Hide, tough as a rhinoceros, insensitive to corrosives, makes this finest of acid pails. Also dippers, bottles, funnels, etc.

ACE *chemical resistant equipment*

BY **AMERICAN** HARD RUBBER COMPANY

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ACE ROAD · BUTLER, N.J.

See ACE equipment in Chemical Engineering Catalog

factory. The unit will burn sulfur, will have a capacity of 376 metric tons/day.

Australia: A plant to produce chemicals and rosin-based emulsifiers will be built at Springvale, near Melbourne, announces Hercules Powder Co., Wilmington, Del. The chemicals will be for paper manufacture, the emulsifiers are slated for use in making synthetic rubber. The plant, due to start up in 1961, will be operated by Hercules Powder Co. (Australia) Pty., Ltd.

U.S.S.R.: Three urea plants will be built for the Soviet Union by the Dutch firm Werkspoor. Firm claims that the plants will be larger than any others in the world.

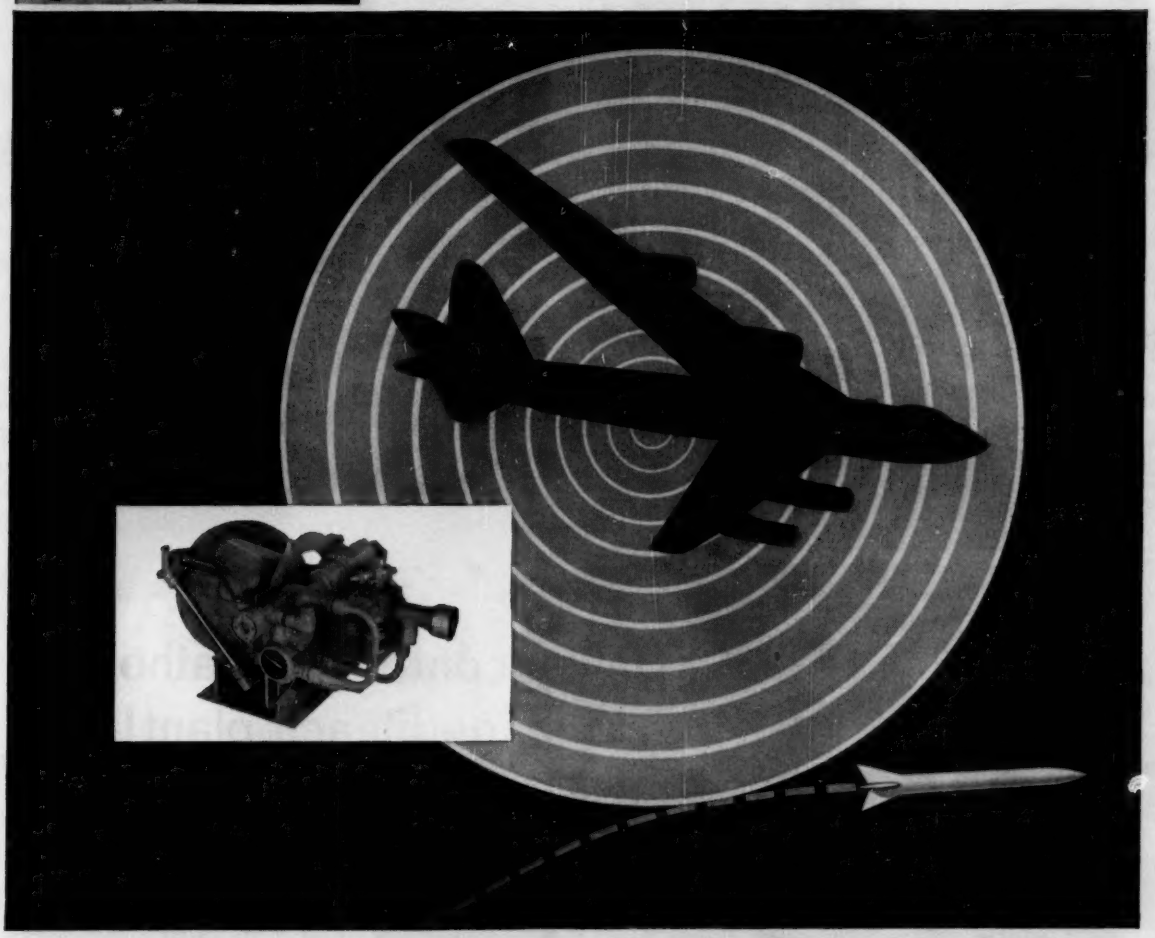
Morocco: Construction has started at Mohammedia, near Casablanca, on a $15-million oil refinery for the Samir Co. Samir is owned equally by Morocco and by Eni, Italy's oil and gas state monopoly, and design and construction of the new refinery is being carried out by the Snam Progetti Co. of the Eni group. Plant is scheduled to go on stream in 1962. It will operate on imported crude until crude produced in Morocco becomes available.

India: Calcutta will be the location of India's first yeast factory, scheduled to start producing early in 1961. Plant will be built by The India Yeast Co., Ltd., a joint venture of Britain's Distillers Co., Ltd., and Shaw Wallace & Co., Ltd., of Calcutta.

Holland: Synthetic-rubber producing facilities of N.V. Chemische Industrie Aku-Goodrich (Ciago) are now being expanded. Ciago is a company jointly owned by B. F. Goodrich Chemical Co. and Algemene Kunstzijde Unie N.V. of Holland. Expansion of the Ciago plant, located in Arnhem, is expected to be completed by early 1961.

3M COMPANY CHEMICALS

THE RAW MATERIALS OF PROGRESS



HOW TO HOLD A JAM SESSION 8 MILES UP

Vickers active cooling system (inset) uses FC-75 in countermeasures system

The increasing sophistication of electronic countermeasures systems poses many problems. Among them—how to cool vital components at the environmental and operational extremes encountered in sonic and supersonic aircraft.

For the Sperry countermeasures system, a new airborne active cooling system—capable of dissipating 47KW in a 74-lb. package—was developed by Vickers using 3M Dielectric Coolant FC-75.

This most stable of all fluids offered to electronics has high electric strength of 37KV. It is self-healing, and maintains electric strength after repeated high voltage arcing. It pours at —148°F and boils at 212°F at one atmosphere . . . ideally suited for evaporative cooling.

Compatible with most materials, FC-75 is non-corrosive, non-flammable, non-toxic, non-explosive and odorless. It is thermally stable in excess of 800°F, and will not form sludges or gums under extremely rigorous conditions. These properties make it ideal as a coolant.

Investigate the remarkable properties of 3M inert fluids in terms of your own product design, miniaturization and performance problems. For free literature, write to 3M Chemical Division, Dept. KAL-80, St. Paul 6, Minn.

CHEMICAL DIVISION

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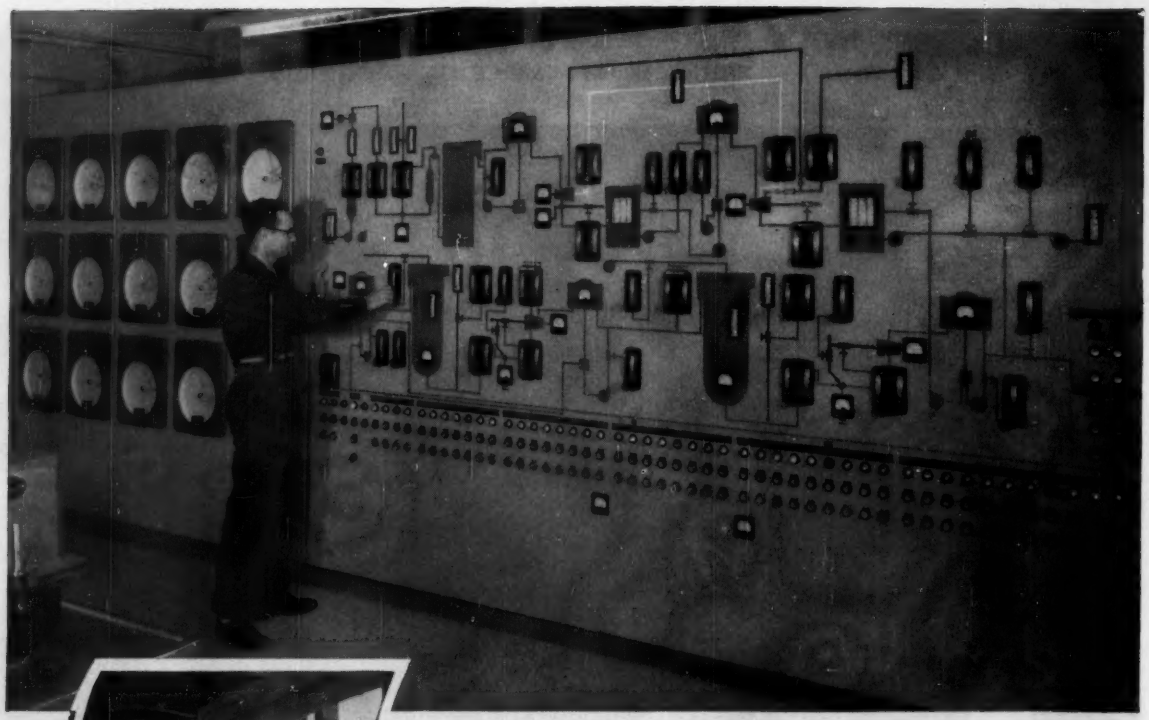
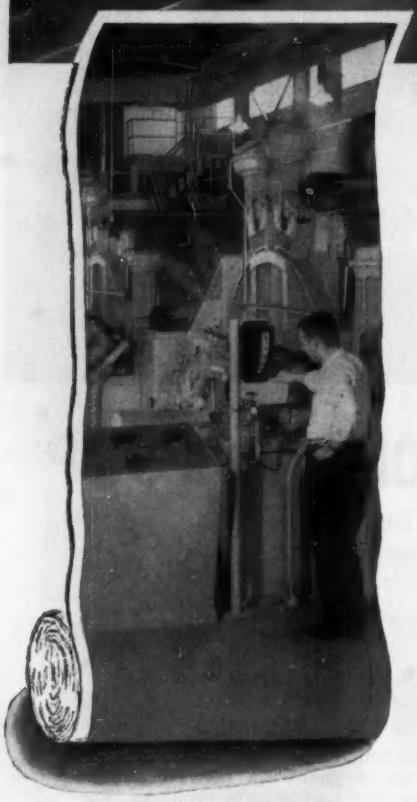
. . . WHERE RESEARCH IS THE KEY TO TOMORROW

3M COMPANY





Photos courtesy Marathon Southern Corporation

Bailey controls Marathon's five-stage bleach plant!

Marathon Southern's five-stage bleach plant at Naheola, Ala., is one of the most completely instrumented in southern U.S.A.

Rigid quality control—automatic and foolproof—keeps production going at top speed with unvarying excellence in the finished product.

The panel board in the central control room (above) was built and instrumented by Bailey. Note how it is divided into two sections. The 15 Bailey Recorders in the recorder section provide continuous circular chart records. The functional graphic panel on its right provides a complete visual picture of the entire process. Important control variables such as stock consistency, stock flow, bleach liquor flows, stock temperatures, etc., can be watched and instantly corrected, either automatically or manually.

At the same station, the operator can supply consistency-controlled stock (from any of four storage towers) to any of the semi-bleach, pine bleach, or gum bleach pulp chests on a ratioed flow, automatically controlled basis.

Each of the five vat bleach washers is equipped with automatic level control (as shown at left).

This is but one example of how Bailey is helping pulp and paper processors to greater degrees of automation, efficiency, and quality control. Let your Bailey Engineer suggest applications to fit your operation. Or write for specific control systems information for your entire plant operation. P149-1

PULP AND PAPER DIVISION

BAILEY METER COMPANY

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In Canada—Bailey Meter Company Limited, Montreal

WORLD RECORD IN ETHYLENE!

Stone & Webster clients produce over
2.3 billion pounds of ethylene annually
in 31 plants in 10 countries.

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experience is available to you.
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GILBARCO'S ELECTRONIC GAUGE

...the only measuring instrument that provides complete automation in gauging liquids and solids!

The Gilbarco Electronic Tank Gauge will indicate the level of most substances having a dielectric constant of 1.5 or higher, which covers virtually every solid and liquid known. Readings can then be transmitted over any distance to a remote station equipped with read-out recorders or data-loggers.

Case histories demonstrate its flexibility...

✔ At a major sugar refinery, a Gilbarco gauge met with acceptable results during a test period...assisting in the automation of this modern plant, a group of gauges will be used to measure continuous sugar level in storage silos.

✔ Polyethylene cubes have been measured successfully.

✔ An electric power plant has purchased a Gilbarco tank gauge for remote measurement of powdered soft coal in feed hoppers.

✔ Gauging of molten sulphur is another application where the Gilbarco unit is being considered.

Alcohol, asphalt, flour, wood pulp, corn and food starches are but a few of the endless commodities that can be measured. Regardless of your product, write to Gilbarco about *your* level measurement problem...

Gilbarco

GILBERT & BARKER MFG. COMPANY
West Springfield, Massachusetts

CALENDAR

Technical Association of the Pulp and Paper Industry, Forest Biology Conference.
Aug. 24-27 Seattle, Wash.

The Combustion Institute, 8th International Symposium, California Institute of Technology.
Aug. 28-Sept. 2 Pasedana, Calif.

Public Health Service, Water Quality Measurement and Instrumentation Symposium, Sanitary Engineering Center.
Aug. 29-31 Cincinnati, Ohio

Air Force Office of Scientific Research, 8th International Combustion Symposium.
Aug. 29-Sept. 2 Los Angeles, Calif.

Chemical Institute of Canada, Nuclear and Radio-Chemistry Symposium, Chalk River Laboratories.
Sept. 6-8 Chalk River, Ontario

Production Engineering Show, Navy Pier.
Sept. 6-16 Chicago, Ill.

Machine Tool Show, International Amphitheatre.
Sept. 6-16 Chicago, Ill.

Massachusetts Institute of Technology, Joint Automatic Control Conference.
Sept. 7-9 Cambridge, Mass.

American Chemical Society, National Meeting.
Sept. 11-16 New York, N. Y.

New York University, College of Engineering, 6th Annual Titanium Metallurgy Conference, University Heights.
Sept. 12-13 Bronx, New York City

Canadian Agricultural Chemicals Assoc., 8th Annual Meeting and Conference, Britannia Hotel.
Sept. 12-14 Muskoka, Ontario

Fifth International Instrument & Measurements Conference & Exhibition, Royal Institute of Technology.
Sept.12-16 Stockholm, Sweden

American Society of Mechanical Engineers. Engineering Management Conference.
Sept. 15-16 Chicago, Ill.

American Society of Mechanical Engineers, Petroleum Mechanical Engineering Conference, Jung Hotel.
Sept. 18-21 New Orleans, La.

American Society of Mechanical Engineers and American Institute of Electrical Engineers, Power Conference, Bellevue-Stratford Hotel.
Sept. 21-23 Philadelphia, Pa.

American Institute of Chemical Engineers, National Meeting, Mayo hotel.
Sept. 25-28 Tulsa, Oklahoma

Instrument Society of America, Instrument-Automation Conference and exhibit, Coliseum.
Sept. 26-30 New York, N. Y.

(*Continued on p.* 180)

True balanced vapor-pressure! That's why NICHOLSON STEAM TRAPS increase Thermal Efficiency . . . and Here's How!

When live steam contacts the bellows of a Nicholson Trap, the pressure inside the bellows equals the pressure outside. With both pressures balanced, the spring action of the bellows closes the trap. When condensate collects around the bellows, pressure inside drops causing outside pressure to compress the bellows and open the trap.

Briefly, this is true balanced pressure and is the operating principle of Nicholson Thermostatic Steam Traps. That's why they discharge condensate and air quickly, positively and intermittently . . . and why they help you get full thermal value from every pound of steam and full productive value from your steam equipment. They provide greater capacity, too . . . up to six times that of ordinary traps. And there's no steam waste either, because seats and valves are of hardened stainless steel, finely ground and accurately lapped for sure, tight shut-off.

As for maintenance, it's practically nil . . . and here's why. In this simply designed trap there is only one moving part. No links, pins, pivots or levers to go wrong. No adjustable orifices to stick, wear or become clogged. No need for valve and seat changing. In short, no downtime because of trap failure.

Naturally, plus efficiency like this does not come at "bargain" prices. You can get cheap traps, of course. But remember this: *price* only shows up on the dealer's shelf; *value* is what shows up on your lines . . . and with Nicholson Traps it shows up in discharge action you can rely on to keep temperatures high and even for full thermal efficiency at point of steam use . . . efficiency that can often increase production as much as 20%.

This is low trap cost, where it really counts. Let's tell you more.

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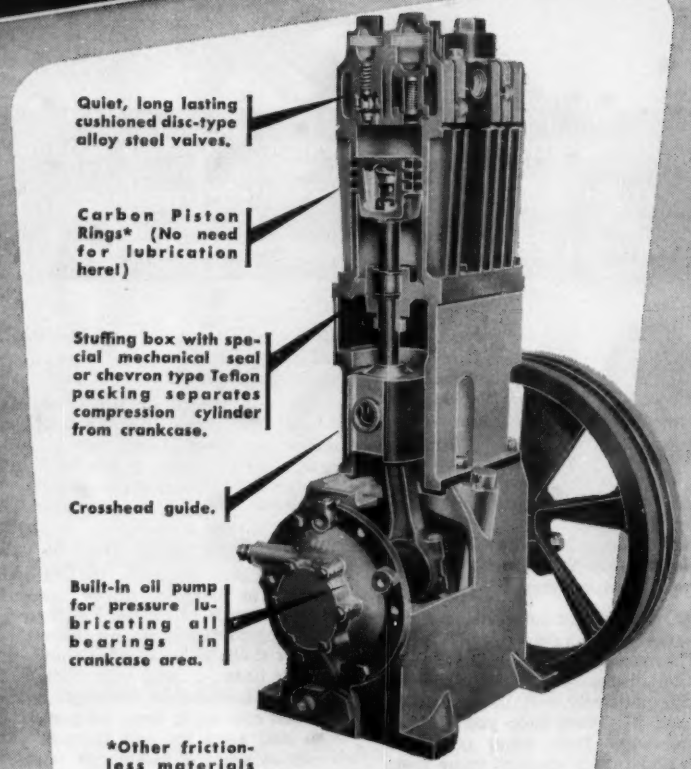
NO OIL CONTAMINATION WITH CORKEN "DRY CYLINDER" COMPRESSORS

Your product is protected by complete separation of cylinder and crankcase!


Quiet, long lasting cushioned disc-type alloy steel valves.
Carbon Piston Rings* (No need for lubrication here!)
Stuffing box with special mechanical seal or chevron type Teflon packing separates compression cylinder from crankcase.
Crosshead guide.
Built-in oil pump for pressure lubricating all bearings in crankcase area.

*Other frictionless materials available.

WRITE FOR BULLETINS VE-100 AND VE-102

Available as single-or two-stage machines—

(Single Stage Duplex)	(Two Stage)
Displacement 4—37 CFM	2—23 CFM

Max. Discharge Press. 265 PSIG—500 PSIG Intermittent

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CALENDAR . . .

International Electrostatics Conference, University of Grenoble.
Sept. 27-Oct. 1 Grenoble, France

Society of Plastics Engineering, Inc., Plastics vs. Corrosion, Mark Hopkin Hotel.
Oct. 5 San Francisco, Calif.

National Association of Corrosion Engineers, six regional conferences.
West, Sheraton-Palace Hotel
Oct. 6-7 San Francisco, Calif.
Southeast, Dinkler-Plaza Hotel
Oct. 6-8 Atlanta, Ga.
Northeast, Prichard Hotel
Oct. 11-14 Huntington, W. Va.
North Central, Pfister Hotel
Oct. 19-20 Milwaukee, Wis.
South Central, Mayo Hotel
Oct. 25-27 Tulsa, Okla.
Canadian (Eastern), Sheraton Mount Royal Hotel
Nov. 14-16 Montreal, Quebec.

American Association of Textile Chemists and Colorists, 1960 National Convention, Sheraton Hotel.
Oct. 6-8 Philadelphia, Pa.

The American Ceramic Society, Refractories Division Meeting, Bedford Springs Hotel.
Oct. 6-8 Bedford, Pa.

American Society of Mechanical Engineers, Rubber and Plastics Conference, Hotel Lawrence.
Oct. 9-12 Erie, Pa.

Electrochemical Society, Annual meeting, Shamrock Hotel.
Oct. 9-13 Houston, Texas

American Vacuum Society, 7th National Symposium, Cleviand-Sheraton Hotel.
Oct. 12-14 Cleveland, Ohio

Industrial Management Society, 9th Annual Methods Improvement Clinic, Conrad Hilton Hotel.
Oct. 12-14 Chicago, Ill.

Industrial Management Society, 24th Annual National Industrial Engineering and Management Clinic, Conrad Hilton Hotel.
Oct. 13-14 Chicago, Ill.

American Society of Mechanical Engineers & American Society of Lubrication Engineers, 7th Annual lubrication Conference, Statler-Hilton Hotel.
Oct. 17-19 Boston, Mass.

Technical Assn. of the Pulp and Paper Industry, 15th Plastics-Paper Conference, Hotel Syracuse.
Oct. 17-19 Syracuse, N. Y.

Institute of Radio Engineers, 1960 Symposium on Adaptive Control Systems, Garden City Hotel.
Oct. 17-19 Garden City, L. I., N. Y.

American Society for Metals, 1960 Metal Show, Philadelphia Trade and Convention Center.
Oct. 17-21 Philadelphia, Pa.

Technical Assn. of the Pulp and Paper Industry, 15th Engineering Conference, Robert Meyer Hotel.
Oct. 23-27 Jacksonville, Fla.

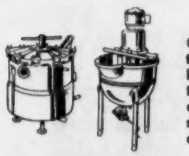
Midwest Research Institute and CHEMICAL ENGINEERING Symposium on new techniques in mathematics, chemistry and engineering as applied to modern chemical engineering practice, Hotel Muehlbach.
Nov. 29-30 Kansas City, Mo.

GROEN

STEAM JACKETED KETTLES

meet every processing and mixing need!

The contrast between kinds of products, where a cook-mix process is employed, staggers the imagination. We frankly don't know how many industries require this type of processing. But if you have a need for minutely controlled temperatures for either heating or cooling combined with thorough mixing or agitating, Groen steam jacketed kettles provide the most efficient method ever developed. Groen engineering research brings you unexcelled heat transfer faster, easier, with substantial savings in time and labor. Groen stainless steel processing vessels are easier-to-clean, too, providing the ultimate in sanitation. There's a size and type for every process or product. Write for complete engineering data and specification sheets.



Complete line includes tanks, coils, vacuum kettles, revolving pans, tubular heat exchangers, pilot plant units and special specification equipment.

GROEN MFG. CO.

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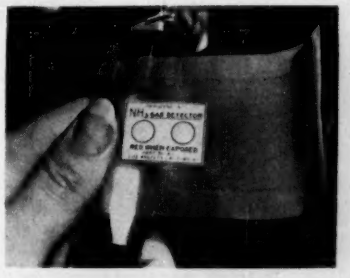
30 Church St., New York 7, N.Y.

(*Continued from p.* 90)

bore, and a stripping column, filled with protruded packing, which may be operated with or without pulsing. Interface may be controlled manually or by an automatic device.

Capacity of pulsed columns depends on many operating variables such as pulse frequency and amplitude, sieve-plate spacing and sieve-plate design. Capacity (organic plus aqueous flows) of ¾-in. I.D. column is about 6 l./hr.—**Chemical Separations Corp., Oak Ridge, Tenn.** 90E



Gas Indicator

Tape stands guard against dangerous gas leakage.

When gas and liquid leak as little as 0.01 cc./hr., a new, flexible, adhesive-backed tape can turn color to warn operators of the danger. Dubbed Tec-Tape, the indicator can be wrapped around joints or simply surface-mounted to warn of random gas leaks.

A special coating on the tape turns a stated contrasting color when exposed to a specific gas or liquid. Tec-Tapes are available for the detection of anhydrous ammonia, chlorine, hydrogen, hydraulic fluids, acid fumes and many other gases.—**Pyrodyne, Inc., Los Angeles, Calif.** 181A

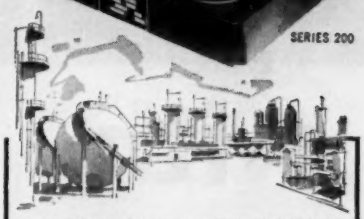
Bunker Vibrator

Arching, plugging stopped by undulating steel strip.

Bins and bunkers up to 50 ft. deep can be emptied of solids

ACCURATE CHEMICAL FEEDING

FROM .65 gph TO 1624 gph



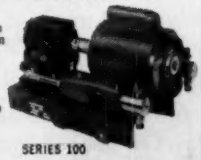
AMERICAN PROPORTIONING PUMPS have repetitive metering accuracy of ± 1% when operating between 10% and 100% of capacity. Feed precisely metered fluids or slurries in all ratios, with controlled process variables.

- interchangeable liquid ends
- spherical self-aligning bearings on crank and crosshead
- crossheads of hardened and ground steel ride on cast iron
- nylon dust covers protect bearings
- NEMA frame motors
- heavy duty reducers

Send for free bulletin.

SERIES 100
Simplex models pump up to 13.10 gph at maximum pressure of 1000 psi. Duplex models double that capacity.

SERIES 200
Simplex models pump up to 812 gph at maximum pressure of 1000 psi. Duplex models double that capacity.



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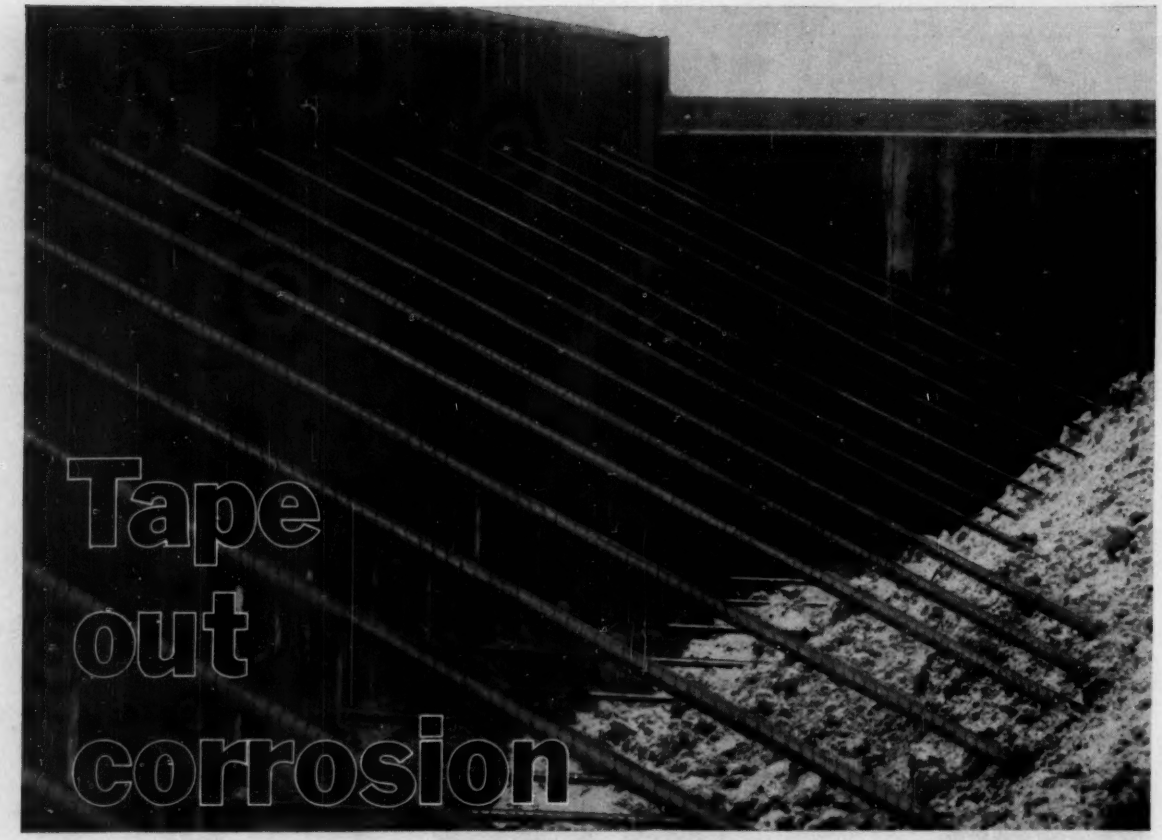

To assure permanent support for this seawall on Lake Michigan, a Wisconsin building contractor wrapped his anchor rods in Polyken tape. Even with an abrasive backfill of wet cinders and ashes, this builder knows Polyken will prevent corrosion and help protect buildings behind the wall.

with permanent Polyken

The durable, doubly thick adhesive of Polyken tape seals all voids—seals out corrosion

Tough, long-lasting Polyken Protective Coatings keep air and moisture from the metal. And abrasion has little effect.

Try Polyken in your plant. Get complete protection for your pipes, conduits, rods—almost anything cylindrical. Polyken is made of an inert polyethylene, with an unplasticized, non-drying film. The unusually high adhesive bonds the coating to clean surfaces without a primer.

Maintenance costs are considerably lower than with paint. Polyken goes on quickly, economically, right from the roll. No heat, no solvents or thinners, no drying or clean-up time. And keep in mind Polyken's lower water vapor transmission rate, higher electrical insulation resistance and better cold-weather handling and durability.

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See your Polyken representative or call the Polyken tape coating distributor near you. Or simply write Polyken, 309 West Jackson Blvd., Chicago 6, Ill. (In Canada, write Polyken, Curity Ave., Toronto.)

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Shutt Process Equipment Co.

Tulsa, Oklahoma
Midwestern Pipe Line Products Co.

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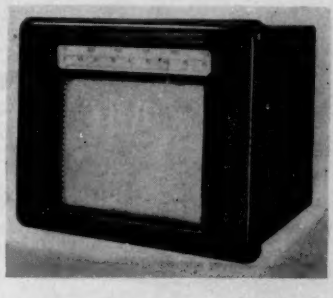
without material holdup at the discharge, according to the manufacturer of a new vibrator. Heart of the device is a long steel strip suspended directly over the discharge opening. When properly vibrated at the top, the whole strip undulates and whips, thus breaking down arches and plugs.

Electromechanical rotary vibrator provides the input to the strip. It works on 220- or 440-v., 3-phase, 60-cycle a.c. power.—**Syntron Co., Homer City, Pa.** 181B



Combination Recorder

Fast-acting unit is completely self-contained.

Using a constant voltage source instead of the conventional standard cell for standardization, a new combination recorder will handle one or more points of pressure and up to 23 points of temperature.

Unit uses a pressure transducer for 0-10,000 psi., and an iron-constantan thermocouple for 0-800 F. Zero and span adjustment are provided. Measuring circuit is electronic, automatically balanced d.c. potentiometer. Accuracy is claimed within 0.25%.—**Barber-Colman Co., Rockford, Ill.** 183A

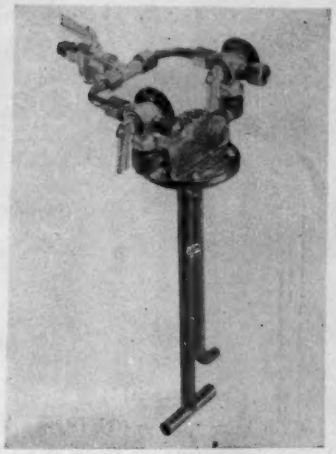
Moisture Monitor

Trace quantities of water in liquids are detected.

Whether present in emulsion or solution, water content of organic liquid streams is continuously measured by a new instrument. The 26-312 Process Moisture Monitor has a range of 1-1,000 ppm.

The unit is divided into two sections. The control portion may be located up to 500 ft. from the analyzer. During operation, water is stripped from a liquid sample with a dry gas in a falling-film column. It is carried by the gas, to react with a desiccant coating connecting two oppositely charged d.c. electrodes.

As long as water is present in the desiccant, current flows between the electrodes. And this flow is directly proportional to the absolute quantity of water present. With slight modification, the unit can be used for batch analysis. — **Consolidated Electrodynamics Corp., Pasadena, Calif.** 183B

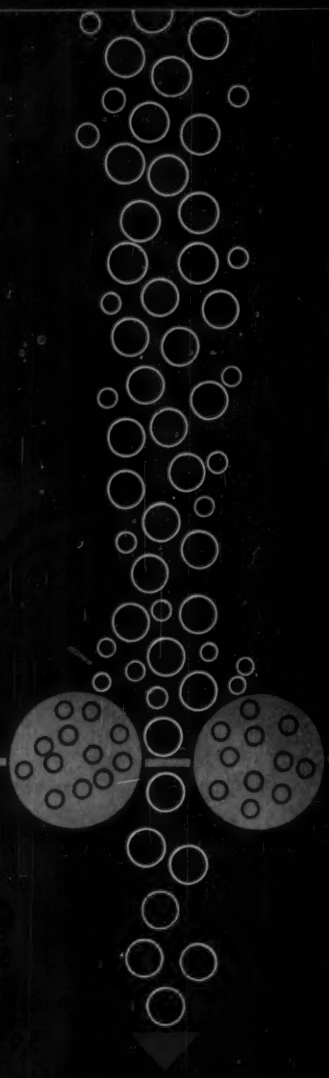


Pitot Tube

Blowout feature clears dirt from elements.

The eternal problem of measuring gas velocity and pressure in dry dust or dirt-laden environments is met with new pitot tube which features its own blowout system. Compressed air, which clears the pressure probe and static pressure element, is controlled by a three-way valve that protects the gage or manometer.

The unit, in brass or stainless steel, works up to 800 F. Design is said to eliminate static openings, pockets, or dead-end spaces where dust might lodge



One-stage purification delivers

ETHYLENE WITH LESS THAN 1PPM OF CO_2

...WHEN YOU ADSORB WITH LINDE MOLECULAR SIEVES

This is only one of many applications which utilize the high capacity and selectivity of LINDE Molecular Sieves. In fact, Molecular Sieves not only outperform other adsorbents, but do other adsorption jobs never before accomplished. Whether in new installations or as replacement adsorbent in existing units, Molecular Sieves can help you minimize both investment and operating costs. More specifically, here's how they are used. . .

A major petrochemical company has reduced the CO_2 content of its ethylene from 3000 PPM to less than 1PPM. This high purity is achieved in a single-stage process, automatic and non-corrosive, which has proved to be more economical than the alternative four-stage process. Other petrochemical uses include drying of cracked gases, ethylene, hydrogen, liquid propylene, solvents and many other gases and liquids. **Natural gas producers** use Molecular Sieves for drying and sweetening of natural gas, for sweetening of liquid propane and butane, and for drying of adsorber oil. **Petroleum refiners** use them to gain efficiency in drying reformer hydrogen, liquid butane LPG and transformer oil, and for removal of impurities such as CO_2 and mercaptans. **Refrigeration manufacturers** use Molecular Sieves as a desiccant in super-drying refrigerants to eliminate freeze-up and corrosion.

For these and many other adsorbent applications, you can rely on patented LINDE Molecular Sieves to perform more effectively. They are the top quality material of their kind available today, always uniform, with high capacity, high strength, and high bulk density. They are available in regular and special grades to meet your specifications.

LINDE technical know-how—gained from years of laboratory and field work with adsorption problems—can help make Molecular Sieves work profitably for you. For further information, write: Dept. CE-084, Linde Company, Division of Union Carbide Corporation, 270 Park Avenue, New York 17, N. Y. **In Canada:** Linde Company, Division of Union Carbide Canada Limited, Toronto 7, Canada.

SOME AREAS WHERE MOLECULAR SIEVES IMPROVE ADSORPTION

- Purification of ethylene
- Drying gases, liquids, solvents
- Drying, sweetening natural gas
- Sweetening liquid propane, butane
- Drying jet fuels
- Octane improvement
- As refrigerant desiccant
- Controlled atmosphere purification

LINDE COMPANY

UNION CARBIDE

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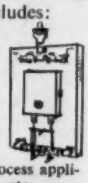
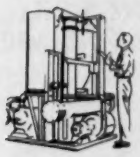
WILLIAM C. DIMAN,
Atmosphere Equipment Specialist, reports . . .

MODERN PROCESSES DEMAND MODERN ATMOSPHERES

Ever since 1927, when C. I. Hayes perfected the first controlled-atmosphere heat treating furnace, we have made a steady effort to further the technology of atmosphere generators and dryers. By recommending proper generators and dryers, we have helped our customers speed production, improve product uniformity and quality and save processing time and trouble. The big Hayes equipment line includes:



MOLECU-DRYER (using LINDE'S Molecular Sieves) — for drying, sweetening, purifying protective atmospheres and for gas and liquid separation and recovery. Exit gas dew points to less than minus 100°F. Many standard sizes available for process applications, instrument air drying, etc.



Linde MOLECULAR SIEVES

NITROGEN GENERATORS (using LINDE'S Molecular Sieves) — produces 99.99% pure inert gas at about 20¢ per 1000 cu. ft. Standard sizes from 1000 CFH to 10,000 CFH.

"ENGINEERED ATMOSPHERES" — HAYES offers a broad range of equipment for producing oxidizing, reducing, carbon-potential, and nitrogen-hydrogen atmospheres . . . also engineered equipment packages for stand-by (start-ups, emergencies, etc.). Standard sizes are available in all types: Exothermic, Endothermic, and forming gas generators — also ammonia dissociators.

Hayes offers more than just equipment. Our Engineering organization and experimental lab. are ready to help make sure you get the right atmosphere equipment for your work.

ASK FOR BULLETINS . . .	Bulletin No.
Molecu-Dryer	5703-A
Nitrogen Generator	5901-NI
Exothermic Generator	256-A
Endothermic Generator	5808-A
Ammonia Dissociator	5810-D
General Bulletin	5810-GC
Forming Gas Generator	256-A

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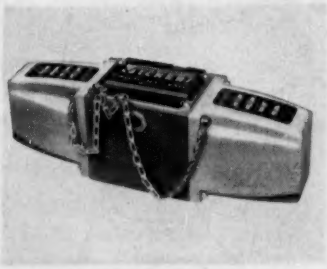
ELECTRIC ATMOSPHERE FURNACES

It pays to see Hayes for metallurgical guidance, lab facilities, furnaces, atmos. generators, gas/liquid dryers.

NEW EQUIPMENT . . .

and resist being blown out. Two-lb. assemblies fit ducts with 6-, 12-, 24-, 36- and 48-in. diameters.—**F. W. Dwyer Mfg. Co., Michigan City, Ind.** 183C

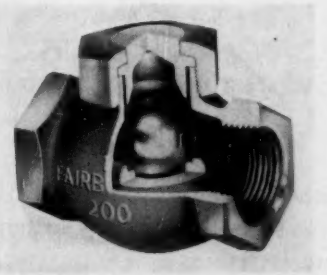


4-Way Control Valve

Air-cooled solenoids operate compact unit.

Solenoids operate a new 4-way directional control valve. The solenoids, which are retained in their covers instead of being mounted separately, are air-cooled, although oil-immersed solenoids are available.

Subplates are furnished with ⅜- or ½-in. ports for flows up to 8 gpm. Maximum operating pressure: 3,000 psi. Solenoids operate on 115 v., 50- or 60-cycle power. Special cushioning is applied to render the valve shock-free.—**Vickers Inc., Detroit, Mich.** 185A

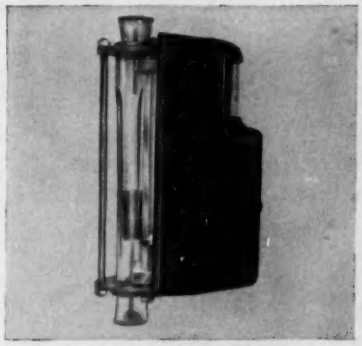


Ball Check Valve

Lift space designed to give full port opening.

A new ball check valve features full port opening for liquid flow. Particularly recommended for service with viscous fluids, valve is also

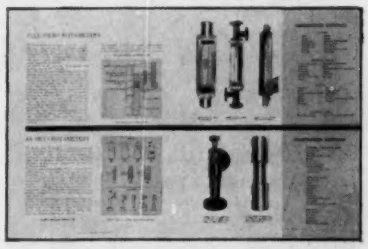
METERING CORROSIVE FLUIDS? Brooks can give you an all-glass *transmitting* rotameter like this . . .



or one with a halofluorocarbon metering tube like this . . .

In fact, we can make a meter to just about any material specifications you might want.

This eight-page bulletin . . .



describes more than a dozen of the many materials available and gives meter construction details. Ask for Bulletin 150, and it's yours.

BROOKS
ROTAMETER COMPANY
860 D STREET
LANSDALE • PENNSYLVANIA

USED TO THINK EVERY STEAM TRAP LEAKED STEAM.
THEN I FOUND ONE THAT DIDN'T, BUT IT WOULDN'T VENT AIR.
FOUND ONE THAT VENTED AIR, BUT IT NEEDED A COOLING LEG.
DISCOVERED A TRAP THAT REMOVED CONDENSATE AT STEAM TEMP, -MAINTENANCE WAS TOO HIGH.
THEN I FOUND A LOW MAINTENANCE TRAP. IT DIDN'T WORK AGAINST BACK PRESSURE.
AT LAST I FOUND ONE THAT WORKED AGAINST BACK PRESSURE, BUT ITS CAPACITY RATING WASN'T DEPENDABLE.
ARMSTRONG PROMISES TRUE CAPACITIES AND EVERYTHING ELSE. SO I CALLED THEM. THEY TOLD ME TO RELAX. I COULDN'T.
THEY TOLD ME ABOUT ARMSTRONG'S GUARANTEE. WHAT'D I HAVE TO LOSE. I TRIED THEM.
EFFICIENCY IS UP, FUEL BILLS ARE DOWN, SO ARE MAINTENANCE COSTS. MAN I'M LIVING!

No one trap can do *everything* better than every other trap. Some traps vent air better than others, some remove condensate faster, etc. But, there is no one trap *best* in every phase of trapping. Armstrong has been manufacturing the Inverted Bucket Trap for nearly fifty years, and though the traps have changed with the requirements of the times, the Inverted Bucket principle has remained. For on overall trap performance, year-in and year-out, nothing beats the Armstrong Inverted Bucket Trap. It's a rugged well-built trap that does *more* things better than any other trap. It's guaranteed because it's been proved.

For more details, see your Armstrong Representative and start living . . .

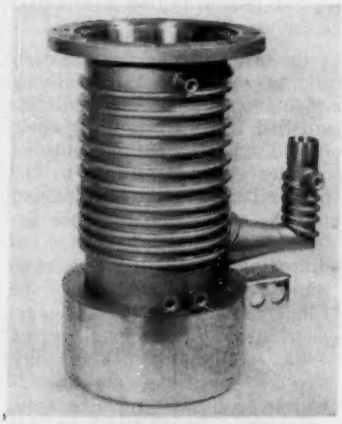
P. S. Like some good meaty reading? Ask for the 48-page Armstrong Steam Trap Book.

ARMSTRONG MACHINE WORKS
8584 MAPLE STREET
THREE RIVERS, MICHIGAN

011-ST

good for steam, water, oil and gas lines. Ball-type valve is said to close faster against pressure than disk-type units.

Long service is claimed for ball valve because sphere has an infinite number of seating surfaces, thus wear is distributed. Valve seat may be resurfaced without removing valve body from the line. For horizontal lines only.—**Fairbanks Co., New York, N. Y. 185B**



High-Vacuum Pump

Improved model is faster, more rugged, more efficient.

Improved performance and decreased operating costs are claimed for a new 6-in. fractionating oil diffusion pump for high-vacuum systems. The new pump is smaller, 70% faster, and works to lower pressures than its predecessor, according to the manufacturer.

The pump's fractionating jet assembly has one ejector and three diffusion stages. Together, they give the unit a speed peak of 1,500 l./sec. between 6×10^{-6} and 5×10^{-4} mm. Hg. Blank-off pressure is 5×10^{-6} mm Hg.

Called H6-1500, the pump features a heavy-wall aluminum jet assembly that is firmly anchored to keep it from being blown into the vacuum valve, if the foreline is accidently exposed to atmospheric pressure. It also has the cooling coils silver-soldered to the body to assure good heat transfer and a permanent bond.

Exposed to field conditions during testing, the pump is designed to operate at full efficiency despite variations in line voltage, cooling water flow and temperature.—**NRC Equipment Corp., Newton, Mass. 187A**

BRIEFS

Boiler preheater-tube cleaner, Rotojet, has an air- or water-driven motor, sliding-pin expanding head and a carbide drill point. Motor is attached to a flexible hose so little headroom is needed to feed tool through entire length of tube. — **Elliot Co., Newark, N. J. 187B**

Sewing attachment simplifies closure of multiwall paper shipping bags. Operator guides full bag into apparatus, which carries the bag to sewing head for automatic stitching. — **Bemis Bro. Bag Co., St. Louis, Mo. 187C**

Equipment Cost Indexes* . . .

	Mar. 1960	June 1960
Industry		
Avg. of all	237.8	238.2
Process Industries		
Cement mfg.	232.4	232.8
Chemical	240.0	240.1
Clay products	225.8	226.2
Glass mfg.	226.6	226.6
Paint mfg.	229.7	229.8
Paper mfg.	231.3	231.3
Petroleum ind.	234.7	234.1
Rubber ind.	237.5	237.6
Process ind. avg.	236.3	236.5
Related Industries		
Elec. power equip.	242.8	242.7
Mining, miling	241.5	241.5
Refrigerating	268.4	268.5
Steam power	224.9	225.0

Compiled quarterly by Marshall and Stevens, Inc. of Ill., Chicago for 47 different industries. See Chem. Eng., Nov. 1947, pp. 124–6 for method of obtaining index numbers; April 4, 1960, pp. 149-50 for annual averages since 1913.

*When the second quarter cost indexes were inserted last issue, some of the numbers were inadvertently transposed. The listing above is correct.—Ed.

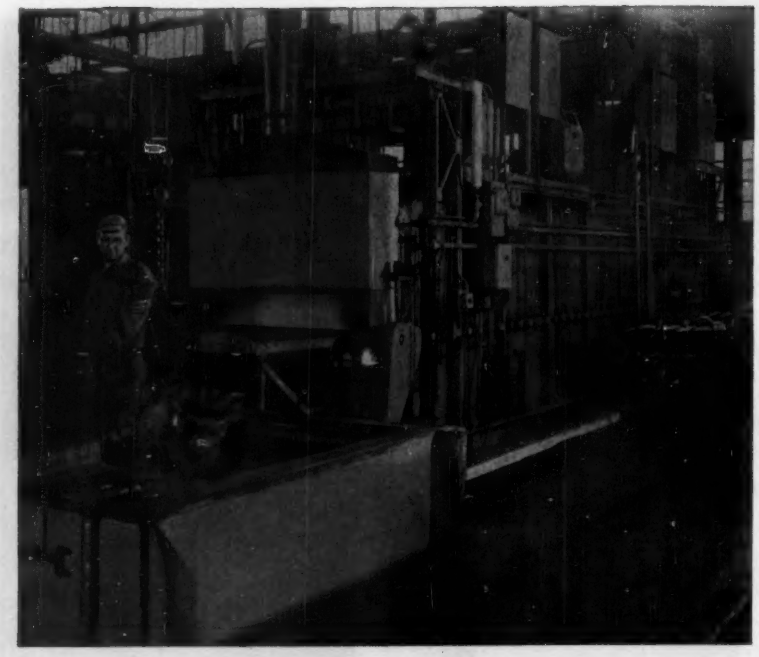
a vacuum pump as quiet as a . . .

Steady and silent. That's the new Stokes Series H Microvac pump. Unique dynamic balancing provides hushed operation. And the compact Stokes pump saves up to 50% in valuable floor space.

Find out all the reasons why you get *more pumping performance per dollar* with Stokes Microvac pumps. Just write: Vacuum Equipment Division, F. J. STOKES CORPORATION, 5500 TABOR RD., PHILA. 20, PA.

STOKES

SEND TODAY for your free Vacuum Slide Calculator.

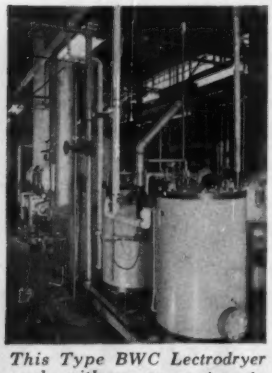


At Caterpillar Tractor Co....

4 new Lectrodryers boost supply of controlled atmosphere to 60,000 cfh

Heat treating furnaces at Caterpillar Tractor Co., Peoria, Illinois, draw on a central source of controlled atmosphere gases for annealing, brazing, carburizing and other metallurgical operations. Five Lectrodryers are now drying 30,000 cubic feet of gas per hour; four more Lectrodryers are being added to almost double the capacity.

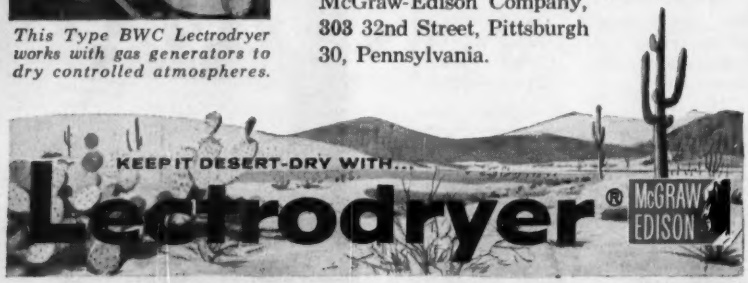
Manifolding the output of several gas generating units gives the flexibility required to service Caterpillar's many controlled atmosphere furnaces. Where those atmospheres must be dry, Lectrodryers lower dewpoints to −20°F.



This Type BWC Lectrodryer works with gas generators to dry controlled atmospheres.

Your gas generator builder

can advise you on equipment for supplying controlled atmospheres. Where dry gas is required, he'll quite likely supply Lectrodryers. *For data sheets* on metallurgical gas drying installations, or for answers on any other drying problems, write Pittsburgh Lectrodryer Division, McGraw-Edison Company, 303 32nd Street, Pittsburgh 30, Pennsylvania.



TECHNICAL

Instruction Tool

ENGINEERING ECONOMICS FOR PROFESSIONAL ENGINEERS' EXAMINATIONS. By Max Kurtz. McGraw-Hill Book Co., New York. 261 pages. $6.50.

Reviewed by John G. Kneiling, Theodore J. Kauffeld Associates, Inc., New York, N. Y.

In its manner of organization and presentation, this textbook is an instruction tool, as distinguished from a reference work. It will appeal to three groups of engineers and aspirants to the profession: (1) those preparing for the professional license examination in most states; (2) engineering-college juniors and seniors seeking to learn the fundamentals of money-management as it affects engineering work; (3) young men in engineering positions seeking to learn the bases on which management money decisions are composed.

The book contains a considerable array of sample problems, typical of questions asked in state license examinations. Included also are many examples, largely taken from classical economics and from utility and governmental engineering economics. And, there are mathematical derivations of equations used in reaching comparison among engineering alternatives.

Level of instruction is approximately that of a standard junior-year text in analytical mechanics or strength of materials. The book undertakes—in this reviewer's opinion successfully—to tell the student how money works, in the same way that a beginner's text on strength of materials tells the student how a beam works. Inasmuch as the engineer's primary function is generally understood to be doing at low cost what anyone else can do at high cost, it is obvious that this subject merits the attention of all who wish to advance in the profession.

BOOKSHELF

The mathematical derivations in this textbook assume an understanding of algebra and the beginnings of differential calculus. But it is written in such a manner that those so inclined may omit the derivations and study the computation methods separately.

The publishers state that this book is directed exclusively to license examination preparation. In this reviewer's opinion, it is also appropriate as a textbook, independent of examinations.

MORE NEW BOOKS

CORROSION DATA SURVEY. 1960 edition. By G. A. Nelson. Shell Development Co. $50.

CHEMICAL PERIODICITY. By R. T. Sanderson. Reinhold. $11.75.

ENGINEERING THERMODYNAMICS. By J. B. Jones & G. A. Hawkins. Reinhold. $8.50.

CONCEPTS OF THERMODYNAMICS. By E. F. Obert. McGraw-Hill. $11.

THE NATURAL PIGMENTS. By K. W. Bentley. Interscience. $5.

MOLECULAR STRUCTURE. By J. C. D. Brand & J. C. Speakman. St. Martin's Press. $8.

THE STORY OF CHEMISTRY. By G. Lockemann. Philosophical Library. $4.75.

THE NATURE OF SCIENCE. By D. Greenwood. Philosophical Library. $3.75.

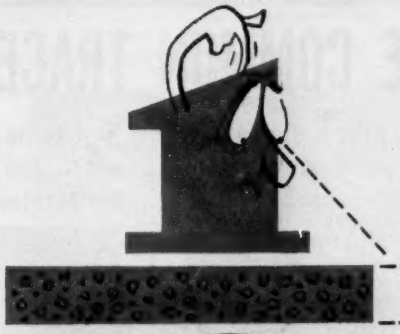
AEROSPACE DICTIONARY. By Frank Gaynor, Philosophical. $6.

NUTRITIONAL EVALUATION OF FOOD PROCESSING. Ed. by R. S. Harris & H. von Loesecke. Wiley. $12.

PHOTOCONDUCTIVITY OF SOLIDS. By R. H. Bube. Wiley. $14.75.

MECHANICAL PROPERTIES OF INTERMETALLIC COMPOUNDS. Ed. by J. H. Westbrook. Wiley. $9.50.

Why pay **FULL** *price for only*



a floor?

CEILCOTE CORROSION-PROOF MONOLITHIC FLOORING GIVES YOU GUARANTEED PERFORMANCE!

INSTALLATION AND MATERIALS ARE EQUALLY IMPORTANT!
You can't buy a bucketful of corrosion-proof flooring! The success of any flooring is determined by correct installation techniques as well as quality materials. Only Ceilcote offers you a *complete flooring service* . . . Corocrete monolithic flooring plus performance guaranteed installations. And Corocrete is scientifically formulated with the proper balance of resins, special aggregates and hardeners to meet your specific requirements!

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SARCO TOPICS

HOW TO SOLVE COMMON TRACER LINE PROBLEMS

How to cure water hammer with a steam trap that will operate in vertical position

Water hammer is an inherent problem in long tracer lines. So is freezing. Both problems can be overcome, and here's an example of how it has been done. At the Socony Mobil Oil Company's Paulsboro, N. J., refinery, they found that the Sarco Thermo-Dynamic Steam Trap, type TD-50, not only withstands water hammer, but installing the trap in a vertical position —which permits free drainage—presents no problems at all, thanks to its unique thermodynamic principle. In fact, 90% of the 250 TD-50's at this plant are vertically mounted. They never block heat transfer, and they remove condensate and air as fast as they collect.

How to handle varied steam pressures— without adjustment

Can a trap—without adjustment — handle steam pressures that vary from 15 to 160 psi? Can the *same* trap vent air and drain condensate as rapidly as it is formed, be easy to install and require practically no maintenance at all? That was the problem set up by the engineering staff of Armour Chemical Division's McCook plant. They solved it by testing many traps. Their conclusion: Sarco TD-50 steam traps meet or beat their specifications, because:
they discharged condensate as fast as it formed, without wasting steam;
their compact inline construction made installation easy, even in tight quarters;
maintenance was practically negligible;
no adjustment was necessary for varying steam pressures. (In fact, the TD-50 is self-adjusting through its full operating range of 10-600 psi.)

No other steam trap can so adequately solve all these problems at one time.

How to be certain process fluid stays above 280° F. when outside temperature drops to —10° F.

The problem of maintaining design temperatures on tracer lines need not be difficult, no matter how extreme the conditions seem to be. For example, the tracer lines in a phthalic anhydride process at Witco Chemical Company's new Chicago plant had to be maintained above 280° F. Below this temperature, the chemical sets and the whole system would have to be taken apart and re-assembled. That's not all; ambient temperatures sometimes could drop to −10° F.

With reliability as a prime consideration, Scientific Design Company, Inc., who designed and constructed this brand new plant, selected the TD-50.

Because the TD-50 can be mounted vertically, freezing was no problem either. Added benefits that matter on tracer lines: the TD-50 is compact, light in weight, easy to install.

What is the most reliable tracer line trapping method to prevent unscheduled shutdown?

Particularly in refineries, steam traps have to function under exactly the kind of conditions that you'd expect to cause failure—they must function equally satisfactorily on low pressure or exhaust steam and on up through high-pressure, high temperature ranges. Not only that, but outside temperature may vary from subzero to subtropical. If maintaining design temperatures in your tracer lines appears to be hampered by these problems, consider how Phillips Petroleum Company, Kansas City, solved them. They found a trap which drains their tracer lines automatically over a full range of pressure, temperatures and loads. It's the Sarco TD-50 Steam Trap.

With only one moving part—a stainless steel disc, the TD-50 has little that can go wrong. In fact, it's so free of trouble that Phillips Petroleum Company consider their TD-50's as reliable and efficient as the piping. They now rely on 1800 of them throughout the plant. 1408

FOR FULL INFORMATION ON TRACER LINE TRAPPING or on any steam trapping problem—see your Sarco Sales Representative or write to

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PLANT: BETHLEHEM, PA.
STEAM TRAPS • TEMPERATURE CONTROLLERS
STRAINERS • HEATING SPECIALTIES

SARCO

Here are 7 Sound Reasons Why the Thermo-Dynamic® Does a Better Job of Trapping

1. *Simplicity*—has only one moving part. 2. *Maintenance*—practically zero. 3. *Wide pressure range*—one trap for all pressures from 10 to 600 psi. 4. *Uniform performance*—operates equally well on heavy, light, or no condensate load. 5. *Operates against back pressures*—up to 50% of inlet pressure. 6. *Rugged*—unaffected by superheat, water hammer, vibration, or corrosive condensate. 7. *Minimizes inventory* of spare parts.

Maintenance Time: 40 Seconds. If it now takes your maintenance crew more than a couple of minutes to service an ordinary trap, you're throwing away valuable time. This Sarco Thermo-Dynamic can be cleaned, blown out if necessary, and reassembled on the line in as little as 40 seconds.

For Prompt Information on the TD-50 . . . or for fast help on the efficient solution of any steam trapping problems, get in touch with a SARCO District Office, Sales Representative, or Distributor. (There's one near you.)

Only SARCO makes all 5 types:
Thermo-Dynamic* • Thermostatic • Liquid Expansion • Float Thermostatic • Inverted Bucket

*U.S. Pat. No. 2,817,353 TM Reg. U.S. Pat. Off. 1409

SARCO
SARCO COMPANY, INC.
415 MADISON AVENUE, NEW YORK 22, N. Y.
PLANT: BETHLEHEM, PA

LETTERS: PRO & CON

C. H. CHILTON

SHIRTSLEEVE SESSION brings together these five new *CE* editors.

Dear Readers:

With this photo we introduce to you the latest additions to our editorial staff.

In the center of this intense little group is Henry S. Gordon, our new copy editor. Hank's job will be to help the rest of us mind our p's and q's—to check our copy for misspelled words, punctuation errors, ambiguities, deviations from standard style—and to help maintain a general, over-all high quality of prose. Hank came to us from a similar job on the staff of *Chemical Week*. He has degrees from University of Virginia and Columbia University, in addition to copy editing experience with other publishers.

Looking over Hank's shoulders are two engineering editors—one a neophyte, the other a veteran. The younger man is Eugene Guccione, who has just received his chemical engineering degree from New York University. Gene did it the hard way—via night school. As a result, he already has had seven years of industrial experience, at Lummus and Pfaudler Permutit.

The veteran is Arthur V. Gemmill, who until July 1 was senior associate editor of *Food Enginering*. When McGraw-Hill sold *FE* to a Philadelphia publisher, Art chose to remain here in New York. Trained and experienced in industry as a chemical engineer, with many years of editorial experience as well, Art will make a valuable addition to *CE's* staff.

At the extreme left and right in the photo are two other alumni of *Food Engineering*. Nancy Pepicello, who was assistant to *FE's* circulation manager, is now handling our editorial makeup. And Dimitrios (Jim) Caratzas, formerly *FE's* art editor, rounds out our expanded Production-Presentation-Copy group. Jim has had over ten years' experience in various art and production jobs with McGraw-Hill.

Not shown in the picture—for good geographical reasons—is

A complete line of integral HP motors: dripproof protected—totally enclosed—and explosion proof

ELLIOTT C-W MOTORS

conservatively designed, ruggedly built, highest quality throughout

The extra service users enjoy from Elliott C-W motors is due to the conservative design, precision manufacture and high-quality materials of these machines. For most applications, the dripproof-protected type gives dependable service. Where conditions are more severe the totally-enclosed or explosion-proof construction may be required. Recently added to the line are the EPA-SEAL epoxy insulated C-W motors for service where moisture or corrosive atmospheres demand superior insulation.

Vacuum-pressure process thoroughly impregnates coils with epoxy resin.

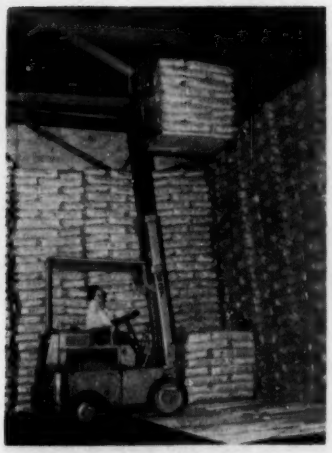
ELLIOTT Company
Crocker-Wheeler Plant
Jeannette, Penna.

WO-2

our new editorial assistant in San Francisco, Terry Shaw. A transplanted Texan with experience in secretarial work and market studies, she is now helping Marty Robbins in his coverage of things chemical in the 13 western states.

These additions bring our editorial staff up to its full authorized strength of 25. We all pledge our best efforts to maintain *CE's* editorial superiority in its service to chemical engineers and the other technical decision makers of the chemical process industries.

CECIL H. CHILTON
Editor-in-Chief
Chemical Engineering



Pro: Warehouse Safety

Sir:

In your May 16 issue (p. 164) you published a photograph which I feel exhibits a certain disregard for safety and fire prevention practices. This photograph showed large, unobstructed piles of material stacked almost to the ceiling and above the chord of the truss, without adequate clearance at floor level.

Place yourself in the boots of an officer of the first fire company to arrive upon answering an alarm. The area is fully involved, you know that the fire is somewhere under the flat roof, but you cannot pinpoint it because of heavy smoke. Inadepate aisle space does not permit ready access, high stacking prevents the proper water pattern from the nozzle being deflected off the underside of the roof, and water damage will be excessive due to use of dunnage rather than 6-in. pallets for drainage purposes.

May I suggest that you analyze the accident and fire prevention aspects of photographs and other types of visual aids before you publish them.

JOHN H. JEBENS
Borden Co.
New York, N. Y.

Sir:

I have discussed Mr. Jebens' letter with our own safety engineers. We feel that perhaps Mr. Jebens has been confused somewhat by the angle at which the picture was taken.

The bags do not appear to be stacked above the lowest roof truss member, and there appears to be sufficient room for deflection of water from the roof for fire-fighting purposes.

The pallet of bags which is immediately next to the roof has not been permanently stacked. It is still on the forks of the lift truck and is meant to show only the handling characteristics of bags stored in this manner.

Furthermore, since the only bags which are visible are stacked against the concrete block walls of the warehouse, we can only assume that the remainder of the warehouse has been loaded properly, with sufficient aisle space for fire-fighting.

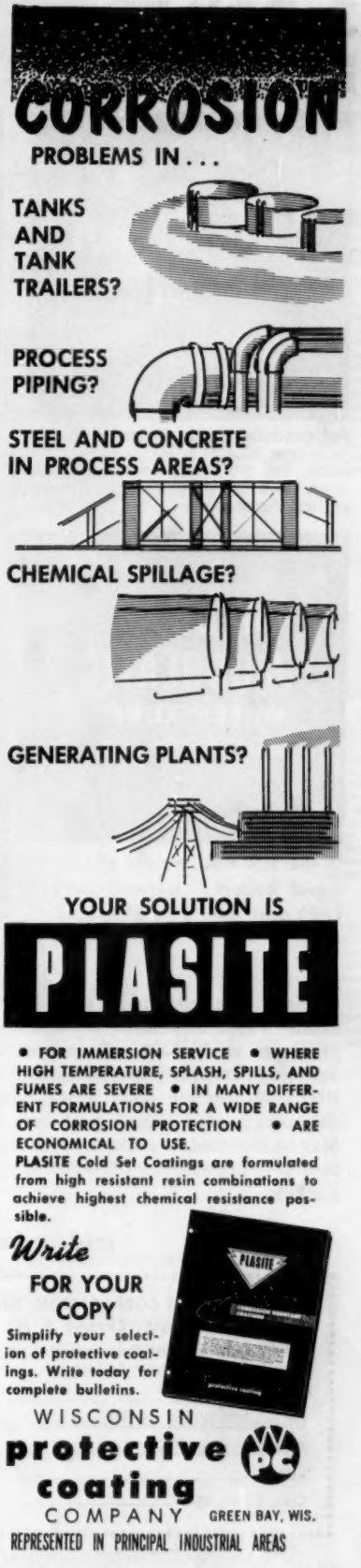
THOMAS E. DOWLING
American Cyanamid Co.
New York, N. Y.

Pro: Submerged Combustion

Sir:

We have read with much interest Mr. Jacobs' article on waste treatment in your May 30 issue (pp. 87-92). We agree with his comment that "the wastes from U. S. industry are predominantly acid in character."

We cannot agree with him that sulfuric acid is the cheapest acid


CORROSION
PROBLEMS IN . . .
TANKS AND TANK TRAILERS?
PROCESS PIPING?
STEEL AND CONCRETE IN PROCESS AREAS?
CHEMICAL SPILLAGE?
GENERATING PLANTS?
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• FOR IMMERSION SERVICE • WHERE HIGH TEMPERATURE, SPLASH, SPILLS, AND FUMES ARE SEVERE • IN MANY DIFFERENT FORMULATIONS FOR A WIDE RANGE OF CORROSION PROTECTION • ARE ECONOMICAL TO USE.
PLASITE Cold Set Coatings are formulated from high resistant resin combinations to achieve highest chemical resistance possible.
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Simplify your selection of protective coatings. Write today for complete bulletins.
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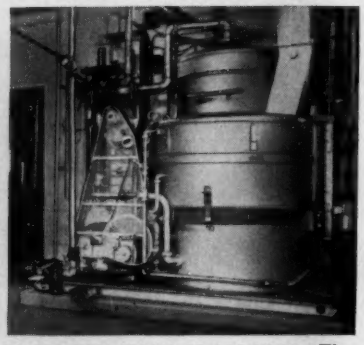
3 BOILERS IN 1 COMPACT PACKAGE!

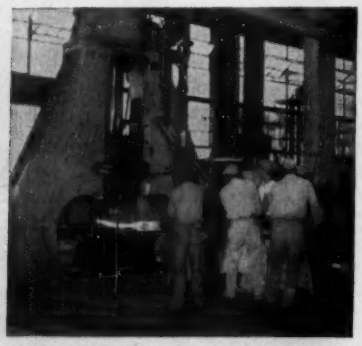
FOR ORDINARY STEAM REQUIREMENTS: The cycle-type Modulātic standard unit furnishes 90% dry steam for most ordinary needs such as cooking, heating water, drying, cleaning, etc.



WHERE DRY STEAM IS REQUIRED: The Modulātic may be used with an optional steam separator, for over 99% dry steam for heating, moulding, forges, operation of power equipment, etc.

VAPOR MODULĀTIC WATER TUBE BOILERS

¼ the size and weight of conventional boilers... largest size (150 BHP) uses only 5' x 8' space.



IF CONSTANT STEAM LOAD MUST BE MAINTAINED: For applications where even a nominal drop in pressure cannot be allowed, an optional steam reservoir may be added to the standard unit to provide a "cushion" during an off cycle.

Efficient... economical... proved in thousands of installations all over the world! Vapor Modulātics furnish high or low-pressure steam (at design pressures up to 1000 psi, or even higher). Lowest installation costs—delivered completely assembled, wired and tested . . . all sizes (40 to 150 BHP) fit through plant doors, with no special foundations or special chimneys needed. Simple push-button operation; built-in safety controls. May be mounted in multiple units to provide for the largest steam requirements—without the inefficiency of idling larger single boilers as demand slackens.

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Please rush me your free bulletins on Modulātic Water Tube Boilers.

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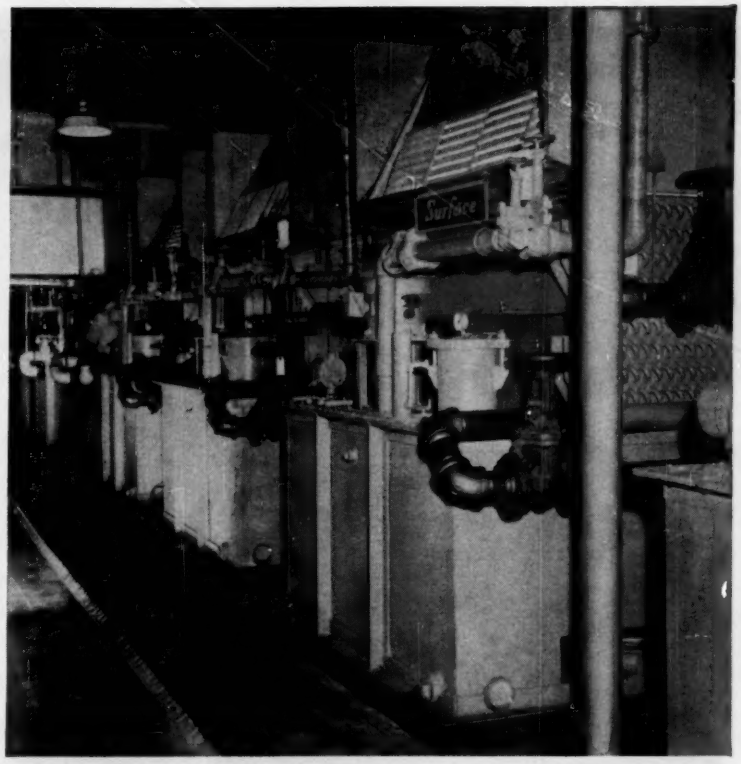

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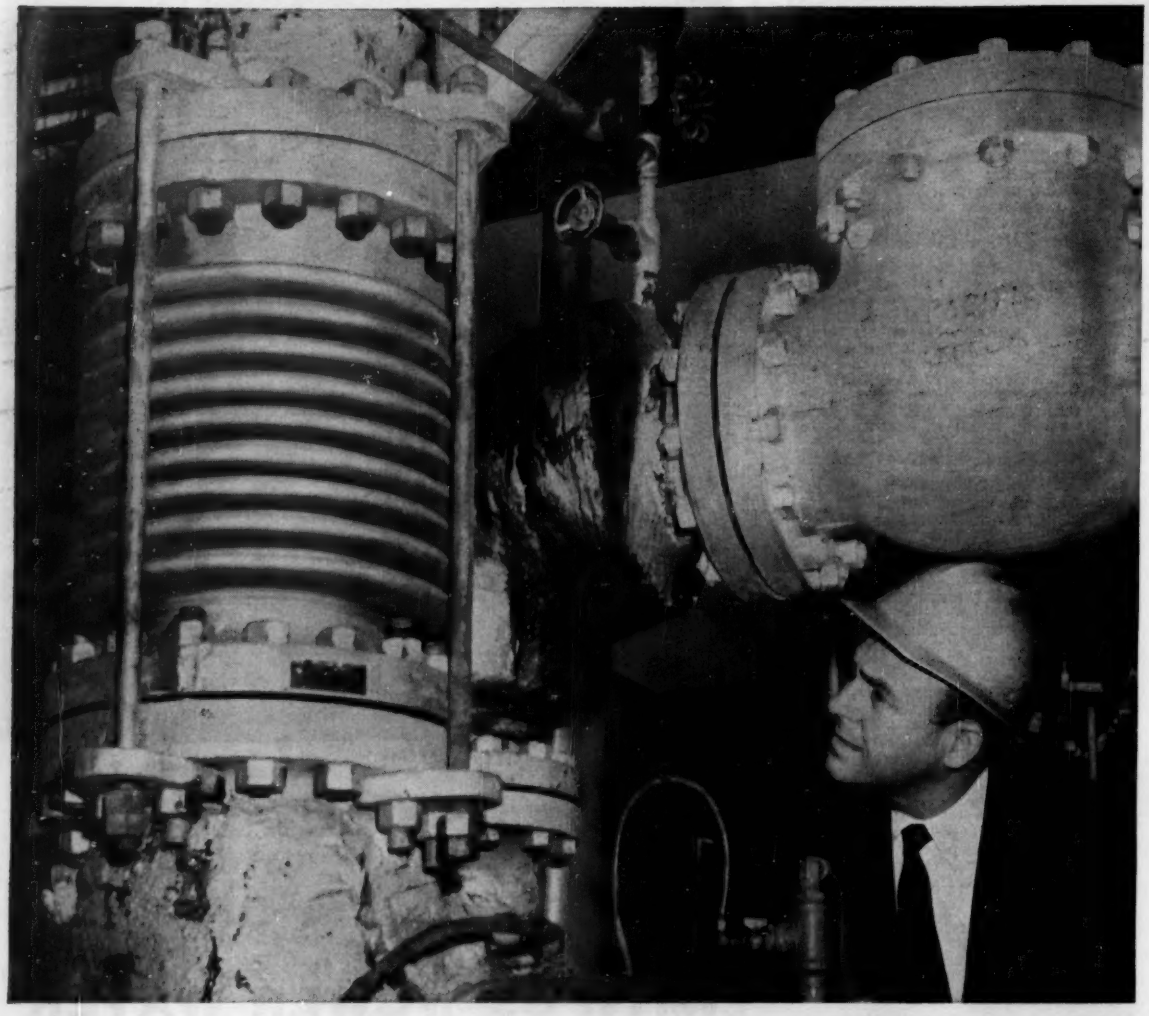

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*From advertisement, this issue

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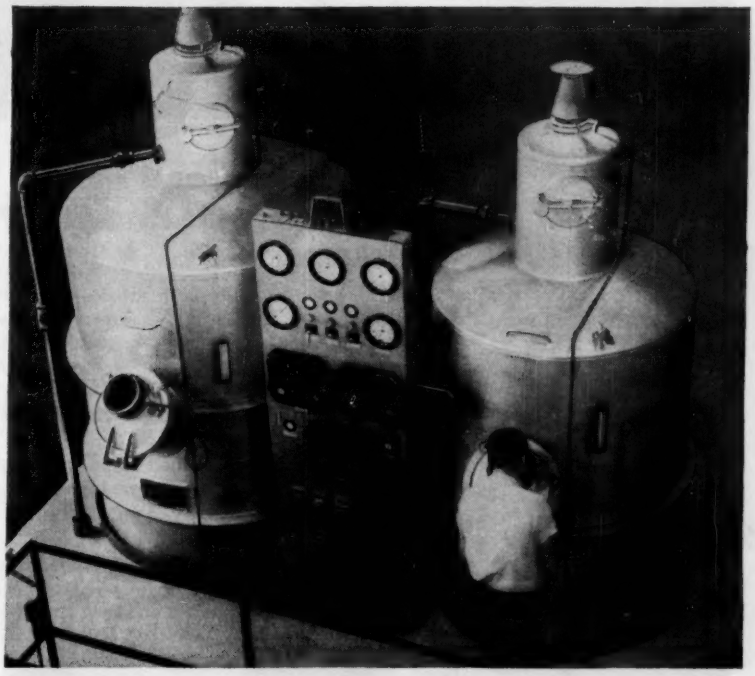


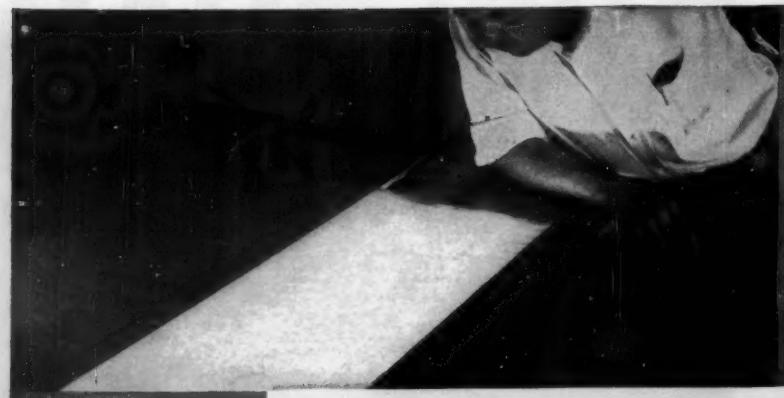
for all chemicals . . .

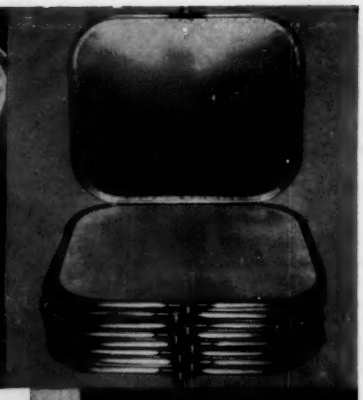
acids, salts, pharmaceuticals, recovery of industrial waste . . .

Whatever your material in process may be, Buflovak Equipment will provide the way to the most profitable operation. The right evaporator, selected from a complete range of designs, can be job-tailored for your product. ■ The Buflovak evaporator line includes: Natural and Forced Circulation, Downflow, Agitated Film Roto-Vak, Crystallizers, Calandrias, Single and Multiple Effects. ■ For details, write for Catalog 372, Buflovak Equipment Division, 1551 Fillmore Avenue, Buffalo 11, New York.

Buflovak Equipment Division

BLAW-KNOX





Who makes and meets your Wire Cloth Specs?

CAMBRIDGE does . . .

To assure you of wire cloth fabrications that give long and satisfactory performance, we have experienced engineers who can draw up prints for your approval if necessary, and trained production men who can quickly and accurately fabricate parts to your most rigid specifications.

To fill your most diversified bulk wire cloth needs, we have thousands of items in stock—in all meshes, wire sizes, metals or alloys—ready for prompt delivery.

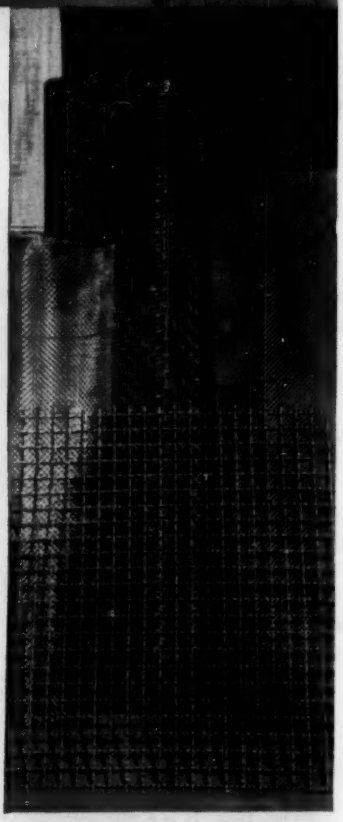
Modern machinery, careful workmanship and constant inspection assure you of exact mesh count and mesh size. And, our field engineers follow up your order to see that our product is giving the best possible service.

We make wire cloth from any metal or alloy—including titanium—in nine basic weaves—from finest to coarsest mesh. Call your Cambridge Field Engineer for information. He's listed in the yellow pages under "Wire Cloth". Or, write for FREE 94-PAGE CATALOG.

The Cambridge Wire Cloth Co.

Department G • Cambridge 8, Md.

Manufacturers of Wire Cloth, Metal-Mesh Conveyor Belts, Wire Cloth Fabrications



Construction Materials

Alloys.....Information about the properties and corrosion resistance of Hastelloy alloy F, contained in a 12-page booklet which is available on request.
163 *Haynes Stellite Co.

Aluminized Steel.....resists a combination of heat & corrosion, gives parts high strength and rigidity, & has high heat reflectivity. Information on Type 1.
204 *Armco Steel

Aluminum Conduit.....solves most corrosion problems in and around chemical plants. It's light weight, nonmagnetic and non-sparking. Additional information available.
10-11 *Rome Cable Div. of Alcoa

Coating.....Plasite is the solution for immersion service, where high temperature, splash, spills, and fumes are severe, & in many formulations for corrosion protection.
193 *Wisconsin Protective Coating Co.

Diatomite.....Celite offers a wide choice of grades each carefully controlled for complete uniformity. It is essentially non-hygroscopic. Tech. data.
59 *Johns-Manville

Insulation.....A complete line of over thirty different specialized insulation products for service from sub-zero to 1900 F. A new catalog is offered.
170 *Baldwin-Ehret-Hill

Insulation.....Styrofoam insulation resists penetration of water & water vapor. Styrofoam cannot rot nor deteriorate & is light-weight. Information.
218 *The Dow Chemical Co.

Insulation.....Calsilite-Hi insulation is ideal for both insulation and fireproofing. Specifications or samples of Calsilite & Calsilite-Hi insulation are available.
46 *The Ruberoid Co.

Insulation, Pipe.....is available in full range of standard pipe sizes & in block form. Single thickness to five inches. Specials to 44" O.D. Bul. No. 65610.
91 *Union Asbestos & Rubber Co.

Matting.....A "You Test It" packet contains instructions for making 7 different tests, abrasion, fire, etc., and even has the mat material to be tested.
203A Natco Products Corp.

Monolithic Flooring.....Corocrete is scientifically formulated with the proper balance of resins, special aggregates & hardeners to meet your requirements. Data.
189 *The Celcote Co., Inc.

Palladium Alloy.....selectively diffuses ultra/pure Hydrogen & blocks all other gases & vapors. Unaffected by repeated heating & cooling in hydrogen. Information.
141 J. Bishop & Co.

Rubber & Plastic Tank Linings..... for alkalies, acids, bleaches, salts. Faultless seams, indestructible bond, shock & age-resistant. Bul. CE-53.
174a *American Hard Rubber Co.

*From advertisement, this issue

NEW...STAINLESS STEEL AUTO-STOP LIQUID METER

It's here! *Automatic formula control* for the batching of corrosive liquids or liquids that must be kept free from contamination! It's the new Neptune Stainless Steel meter with all-stainless, Auto-Stop valve. The register watches the delivery, automatically trips the valve shut at the exact quantity. Valve is mechanically coupled...no inaccuracies due to time-lag in cut-off.

Saves time, ingredients, labor...puts end to spoiled batches...cleans up hazardous or messy conditions...provides accurate cost records. Accuracy is completely protected from effects of corrosion or corrosive wear. Only two moving parts in meter contact liquid. Gear train is outside the casing, isolated from liquid.

Size 1½", capacity 20 to 100 gpm. Also available with repeating Auto-Stop that "remembers" formula, and with ticket printing and electrical Auto-Switch combinations.

NEPTUNE METER COMPANY
Liquid Meter Division
47-25 34th St., Long Island City 1, N. Y.

neptune

Branches in: ATLANTA • BOSTON • CHICAGO • DALLAS
PORTLAND, ORE. • LONG ISLAND CITY • DENVER
NO. KANSAS CITY, MO. • LOS ANGELES • LOUISVILLE
SAN FRANCISCO (Millbrae) • PHILADELPHIA (Bala Cynwyd)
In Canada: Neptune Meters, Ltd., TORONTO 14, ONT.

WF

ASK FOR BULLETIN 94/10.
Got a job in mind? Give details and we'll gladly give recommendations.

Why and where

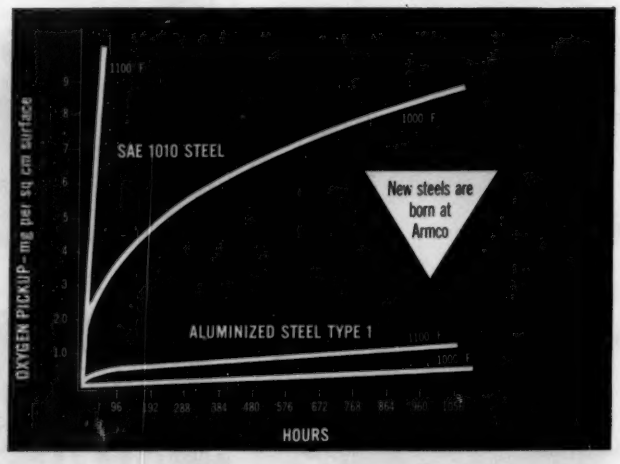
Armco ALUMINIZED STEEL Type 1

Resists heat and corrosion

Oxidation rates for ALUMINIZED STEEL Type 1 show why this special hot-dip aluminum-coated steel resists heat. The unique aluminum-on-steel material also effectively resists a combination of heat and corrosion, gives parts high strength and rigidity, and has high heat reflectivity.

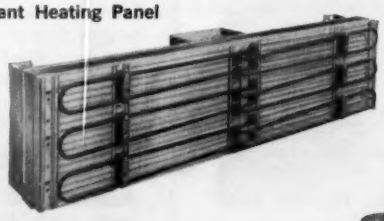
In chemical plant equipment such as burner shields, reactor covers, fume oxidizers, ductwork, radiant heating panels, ovens, and engine mufflers, Armco ALUMINIZED STEEL Type 1 is yielding longer service life than any other metal in its price class.

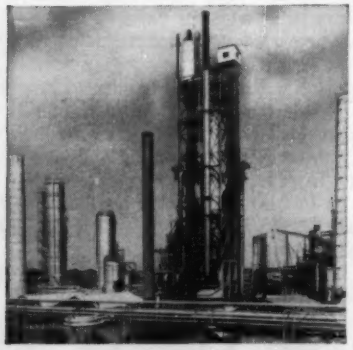
Perhaps *you* can save money or improve the processing equipment you make or use with Armco ALUMINIZED STEEL Type 1. It will pay you to get complete information on this special Armco Steel. Just write us. Armco Steel Corporation, 2590 Curtis Street, Middletown, Ohio.



Oxidation rates of ALUMINIZED STEEL Type 1 and SAE 1010 steel at 1000 F and 1100 F.

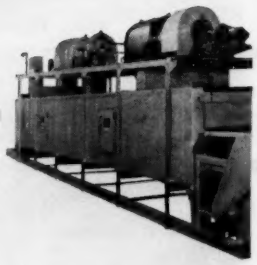
Radiant Heating Panel





Stack Shield

Drying Oven



ARMCO STEEL

Armco Division • Sheffield Division • The National Supply Company • Armco Drainage & Metal Products, Inc. • The Armco International Corporation • Union Wire Rope Corporation

Stainless Steel.....The aspects of the manufacture of stainless steel, its machining, and the types and sizes available from this company are pictorially described.
205A G. O. Carlson, Inc.

Silicone Rubbers.....A new publication describing product and application data on the complete family of RTV (room temperature vulcanizing) rubbers is now available.
205B General Electric Co.

Wire Cloth.....for your most diversified bulk wire cloth needs. Thousands of items in stock in all meshes, wire sizes, metals or alloys. A 94-pg. catalog offered.
202 *The Cambridge Wire Cloth Co.

Woven Wire Cloth.....This catalog is illustrated with many examples of fine mesh strainers, flat strainers, perforated metal stampings and strainers with special fittings.
205C F. P. Smith Corp.

Zinc Dust.....is now being used as a reducing agent, precipitating agent, purifier, catalyst, polymerizing agent, & in rust-resistant paints, bleaches, etc. Information.
93 *American Smelting & Refining

Electrical & Mechanical

Electro Pneumatic Transducer..... developed for use in electrical control loops where the final control element is pneumatically operated. Information on Type 543.
111 *Fisher Governor Co.

Electrical Operators.....A new 4-page booklet which tells how to apply electrical operators for the remote control of circuit breakers is now available, gratis of course.
205D Westinghouse Electric Corp.

Enclosures.....Spin Top enclosures are available in three ways; complete device, enclosure only, or components only. Details in Bulletin 9990.
57 *Square D. Company

Gear and Speed Reducer.....The publication of a 246-page gear and speed reducer catalog is announced which contains information on sizes, ratings and specs.
205E The Ohio Gear Company

Motors.....are offered in a wide range of sizes, horsepowers, speeds . . . for a multitude of applications. Offered with & without internal gearing &/or variable speed drives.
97 *U.S. Electrical Motors Inc.

Motors.....Type EP and Type JP totally-enclosed fan-cooled motors are build in ratings through 100 hp in NEMA frame sizes 182-445U. Bulletin MU-224.
206 *Wagner Electric Corp.

Motors & Generators.....A copy of the data and specification file on Electric Motors and Generators is now available for your ready reference on request.
31 *Marathon Electric Mfg. Corp.

Piston Ring.....Sixteen-page catalog describes the complete line of piston rings. Also the special rings of the Airtomics Division. Available on request.
87 *C. Lee Cook Co.

*From advertisement, this issue

20 tons

OF OIL-SMOOTH PULLING POWER

NEW Snap-on Hydraulic Puller saves downtime, cuts costs

The new SNAP-ON 20-ton hydraulic puller handles hundreds of pushing, pulling and pressing jobs quickly and safely. No more galled shafts — no more damaged parts through heating, prying or hammering. Even the tightest pressed fits are off with a few easy strokes of the handle — downtime can be cut from hours to minutes.

Hydraulic ram is threaded near the top for attachment of various yokes and adaptors for different jobs. Ram and adaptor can be used on the outside of a puller yoke. This is an exclusive feature and provides 6-in. longer reach than competitive units.

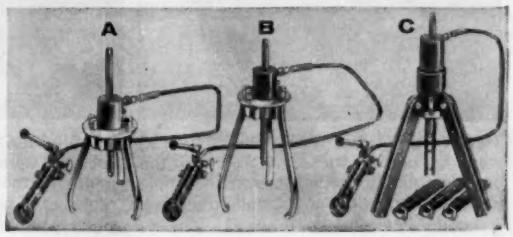
Another important feature is the accumulator sack on the pump. It permits operating pump in any position, eliminates back pressure and keeps oil free from contamination.

Ram and pump assembly is available separately or with your choice of a wide range of pullers — combination 2- and 3-jaw yoke-type, bar-type, and floor press, together with wide assortment of adaptors. Many of the SNAP-ON pullers you now have can be used with this hydraulic set. Get full details from your SNAP-ON representative or write for new literature.

FOR ALL INDUSTRY

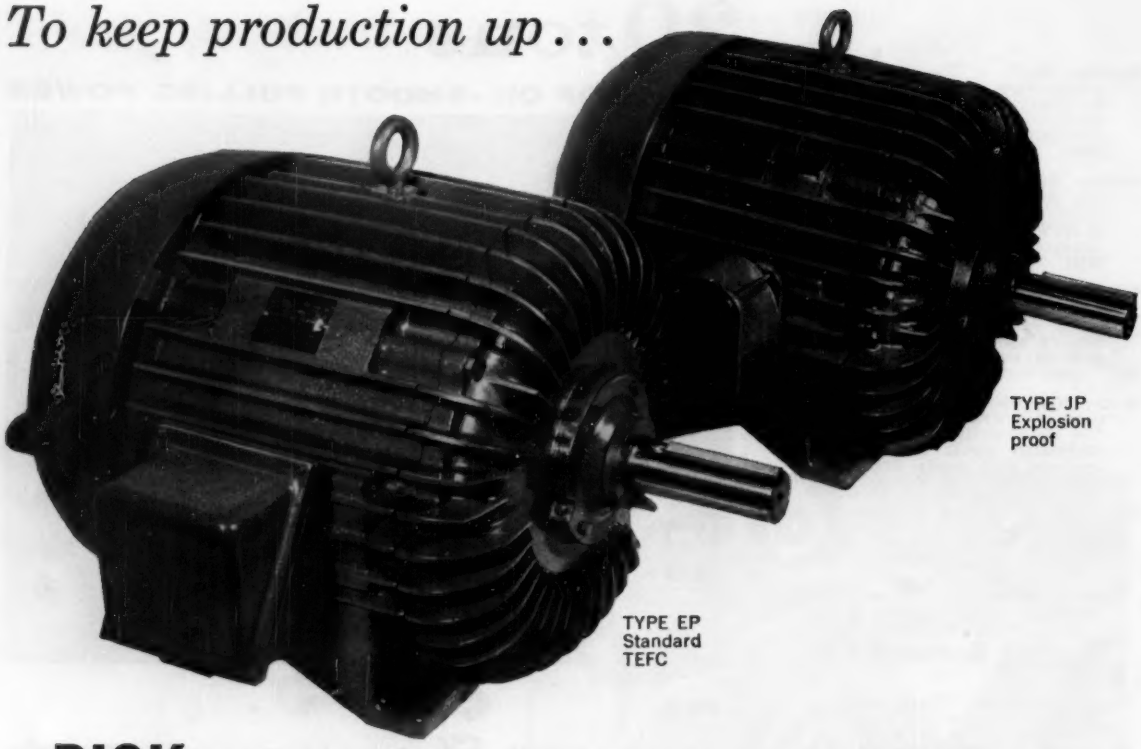
SNAP-ON TOOLS

8106-H 28TH AVENUE • KENOSHA, WISCONSIN



SNAP-ON CG-420 ram and pump assembly shown with A, the CG-400 puller with 9½-in. reach and 13-in. spread; B, the CG-405 puller with 14-in. reach and 15-in. spread; C, the CG-425 heavy-duty puller with 19-in. reach and 20-in. spread.

To keep production up...



PICK FROM THIS PROTECTED PAIR...

Here's a power-packed pair of Wagner® totally-enclosed fan-cooled motors —Type EP, standard, protected against damage from dust, abrasive, fumes, steel chips or filings; and Type JP, explosion-proof, for safe use in specified hazardous locations.

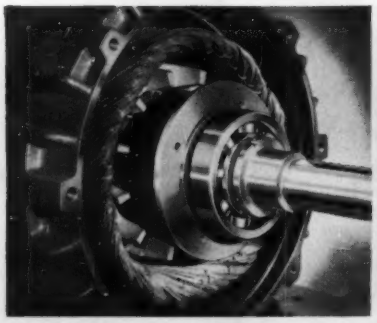
They'll keep your production rates up, delivering full rated horsepower under the toughest conditions . . . staying on the job with dependable, continuous service that means peak output. They're the perfect pick, for individual machines or for automated lines.

In the design illustrated, these motors are built in ratings through 100 hp in NEMA frame sizes 182-445U. Let your Wagner Sales Engineer show you how this protected pair (or larger Wagner enclosed motors through 500 hp) gets the job done. Call him, or write us for Bulletin MU-224.

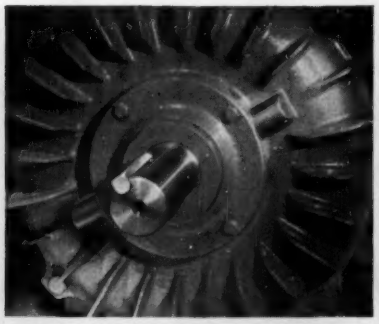
Wagner Electric Corporation

6407 PLYMOUTH AVENUE, ST. LOUIS 33, MISSOURI

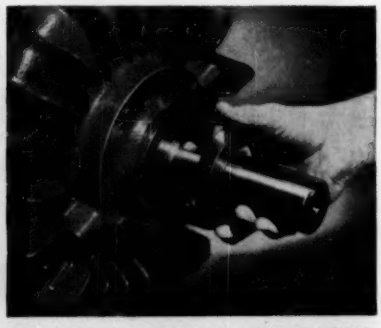
WH60-19



HEAVY-DUTY BALL BEARINGS... The ball bearings used in these motors are of the highest quality, with more than ample capacity to provide long, troublefree service under heavy loads.



BEARINGS CAN BE RELUBRICATED... Factory lubrication will last for many years under normal service, but openings are provided to permit relubrication that adds years to motor life under severe conditions.



SECURELY SEALED FOR LOW MAINTENANCE... Both ends of these motors have running shaft seals to keep the bearings clean. Bearing housings are effectively sealed to prevent escape of grease.

Pullers.....New 20-ton hydraulic puller handles hundreds of pushing, pulling and pressing jobs. Full details contained in new literature which is offered.
205 *Snap-On Tools

Speed Variators.....Bulletin GEA-7019 contains descriptions of "Thymotrol" drive to machine feed and spindle applications, reeling equipment, and other applications.
207A General Electric Co.

Turbines.....with a totally enclosed governor . . . totally enclosed, independently operated safety trip . . . easily replaceable packing & bearings, etc. Further facts Cat. 200.
143 *Coppus Engineering Corp.

Turbine-Driver.....Low-speed turbine drives will meet your requirements. Bul. S-140 covers the full line of Terry turbines and the S-130.
38 *The Terry Steam Turbine Co.

Handling & Packaging

Conveyor Belts.....The Solarflex is designed specifically for handling hot materials. Full information on this hot-material belt is available on request.
1 *B. F. Goodrich

Conveyor Drives.....The unit's cast-in base makes drives adaptable to conveyors of all types, agitators, screw conveyors, machines, & for any other transmission of power.
105 *Morse Chain Co.

Conveyors.....Data on all types of conveyors to meet your materials handling needs plus components, accessories from stock. Available on request.
92 *The Jeffrey Mfg. Co.

Equipped Haulers.....Provides containers and service for small fee. Brochure describes their service in detail. Name of nearest private hauler on request.
26 *Dempster Brothers

Lift Trucks.....for fire safety or material handling. Bulletin BU-638 on DX safety diesel lift trucks with 3000 to 8000 lb. capacity is available.
101 *Allis-Chalmers

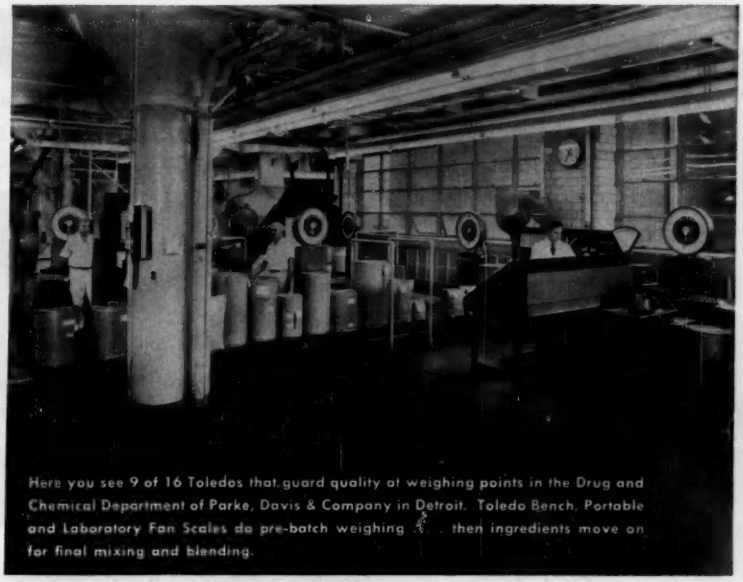
Materials Handling.....The H-25 Payloader features 2,500 lb. operating capacity, power shift transmission, torque-converter drive, power-steering, etc. Data.
43 *The Frank G. Hough Co.

Scales.....Complete information on how modern scales will fit your needs . . . whatever your weighing problem is contained in Condensed Catalog 2001.
207 *Toledo Scale

Trucks, Industrial.....A package of 4 booklets tells how to find out the cost of owning and operating industrial trucks, including propane and electric powered ones.
207B Exide Industrial Division

Vibrating Feeders.....The feeders described are designed especially for iron and non-ferrous ores, coal, rock, slag, shale, clinker, gravel and foundry sand feeding.
207C Link-Belt Co.

*From advertisement, this issue



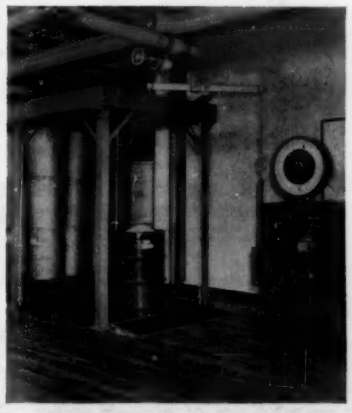
Here you see 9 of 16 Toledos that guard quality at weighing points in the Drug and Chemical Department of Parke, Davis & Company in Detroit. Toledo Bench, Portable and Laboratory Fan Scales do pre-batch weighing . . . then ingredients move on for final mixing and blending.

TOLEDO SCALES
meet PARKE, DAVIS & COMPANY'S
Critical Standards . . .

Parke, Davis & Company brings to doctors and patients wonders in the world of medicine . . . products that help extend the span of human life . . . alleviate suffering . . . and thwart sickness and disease. It's a 94-year tradition at Parke, Davis & Company to keep going forward — in research and in methods and equipment used in their laboratories.

You'll see evidence of this company's progress in the choice of modern Toledos for fast, accurate control at weighing points. Putting Toledos in these vital jobs of weight-control assures that right amounts of drugs and chemicals go into each carefully determined formula — every time!

Let us show you how modern Toledos will fit your needs equally well — whatever your weighing problem. Write today for new Condensed Catalog 2001.



● Toledo Model 2282 Suspended Platform Scale weighs drug materials going into batches in the Crude Drug Milling Section of the Extract Department.

TOLEDO SCALE, TOLEDO 12, OHIO
Division of TOLEDO SCALE CORPORATION
(Toledo Scale Company of Canada, Ltd., Windsor, Ont.)

SERVICE Factory-Trained 240 Cities

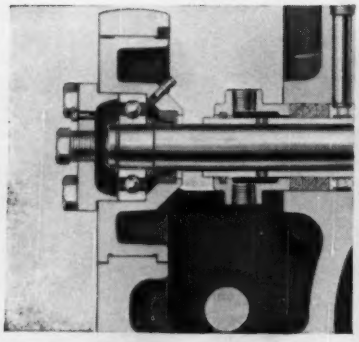
TOLEDO®

Weight-printing Scales • Motor Truck Scales • Automatic Batch Controls • Bulk Weighers • Automatic Check Weighers • Electronic Load Cell Scales • Counting Scales • Mailing and Parcel Post Scales

Headquarters for Weighing Systems

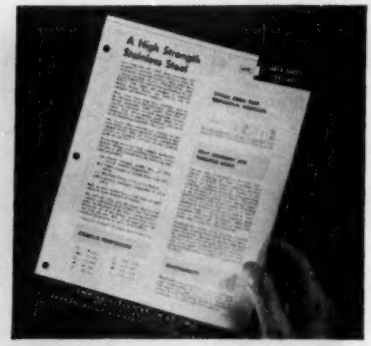
PUMPAGE

Goulds news about pumps for process industries



When life hangs by 5/1000 of an inch

Whether life is long or short depends on the proper fit of shaft to bearing. Destroy the fit by 5 to 10 thousandths of an inch—and you shorten bearing life. Therefore Goulds pump shafts are ground and polished to within the tolerances specified by bearing manufacturers. To insure complete accuracy, bearing housings are bored by a special machine. Careful handling when removing and replacing bearings in the field will also go a long way toward protecting fit and helping bearings live to a ripe old age.



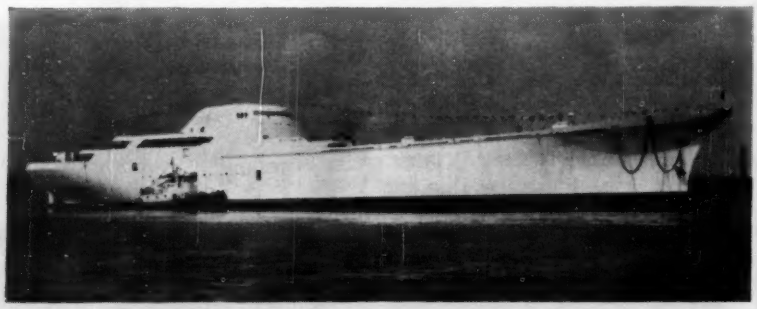
Now... ISO-40 to guard against corrosion and abrasion

A stainless of great strength, ISO-40* alloy survives under some very harsh conditions. Strongly oxidizing nitric solutions don't faze it. It's a match for 50% sulfuric at r.t. It resists corrosion, abrasion, high shock. Can be furnished with a B.H.N. hardness of 320, tensile strength of 145,000 psi. A pump with an ISO-40 impeller circulated a slurry of sodium sulfite and sodium carbonate for 17 months with negligible impeller damage. Speaking of pumps, did you know you can get Goulds chemical pumps in ISO-40?

*Registered trademark of Empire Steel Castings, Inc.

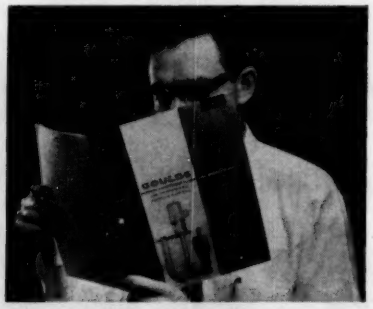
Circulating crude phthalic anhydride

One company does it with two Goulds Model 3171's. Each delivers forty gallons a minute of this sluggish solid (sp. gr. 1.2) from a depth of 11 ft. at temperatures from 300 to 525 F. How? The discharge pipe, which extends from pump through pit cover, wears a steam jacket. Temperature stays up—phthalic anhydride stays fluid. The long pipe has a 3″ expansion joint. Additional steam-jacketed pumps of other and varying lengths give flexibility to the installation. For details on how Goulds Model 3171's can help *you* move uncooperative solids, write for Bulletin 726.2.



Nuclear nomad of the seven seas

N. S. Savannah, first atomic-powered merchantman, will call at the seaports of the world as a symbol of the peaceful use of nuclear power. The 21,800-ton ship has a practically foolproof power plant. Its pressurized-water nuclear reactor uses uranium oxide fuel. Goulds Model 3655 (close-coupled centrifugal) pumps the radioactive waste water on both bilge and ballast service. The Model 3655 is available in 23 sizes with capacities to 2000 gpm, heads to 400 ft. Pump and motor are a single, compact unit, easy to install and ready to run. Standardization of parts holds down inventories. For full details, including specifications, construction information and performance charts, write for Bulletin 710.1.



NEW "king-size" vertical... capacities to 3180 gpm

Here are all the details on Goulds newest heavy-duty centrifugal sump and process pump—the "L" size Model 3171. Unit available in 316 stainless and other special alloys. Specifications, sectional views, construction materials, performance curves, dimensions—all are clearly given in Bulletin 726.2. For your copy, write Goulds Pumps, Inc., Dept. CE-80, Seneca Falls, N. Y.

GOULDS PUMPS

Heating & Cooling

Boilers.....Vapor Modulatic water tube boilers furnish high or low-pressure steam (at design pressures up to 1000 psi, or even higher). Bulletins offered.
194 *Vapor Heating Corp.

Boilers.....Package water tube boilers are available in oil and/or gas fired types in standard pressures of 175,250 and 375 pounds per square inch gage. Literature.
139 *Henry Vogt Machine Co.

Heat Exchanger Tube.....Brochure includes technical information on the use of copper alloy tubes in condensers and heat exchangers. Also chart of tube alloys.
209A Scovill Mfg. Co.

Heat Exchangers.....Standard type are suitable for a wide range of services. Complete guide to the selection of a standard heat exchanger is contained in Bul. B-20.
83 Struthers Wells Corp.

Heat Transfer.....A 20-page booklet in three colors gives the properties of 6 common vapors, including steam, ammonia, and the properties of brines.
209B Chemetron Corp.

Heat Transfer.....New Multi-Zone Platecoil offers operating pressures up to 250 psi in all kinds of tank and process heating. Bulletin P 61 for more data.
113 *Tranter Mfg., Inc.

Heat Transfer Equipment.....Details on engineering, fabrication and erection for guaranteed heat transfer equipment is available now on request.
167 *Chicago Bridge & Iron Co.

Heating & Cooling Coils.....made to your exact specifications to heat & cool fluids, to condense gases, to evaporate liquids, etc. Information on all equipment.
213 *Marlo Coil Co.

Heating Systems.....Aroclor systems deliver steady process heat. Information booklet on Aroclor 1248 heating systems and guide to heater selection offered.
169 *Monsanto Chemical Co.

Kilns, Rotary.....have all welded steel shells, feed & discharge end seals, heat recuperating chain systems for wet process kilns, improved kiln feeders, etc. Bul. 1115.
30 *Traylor Engr. & Mfg. Co.

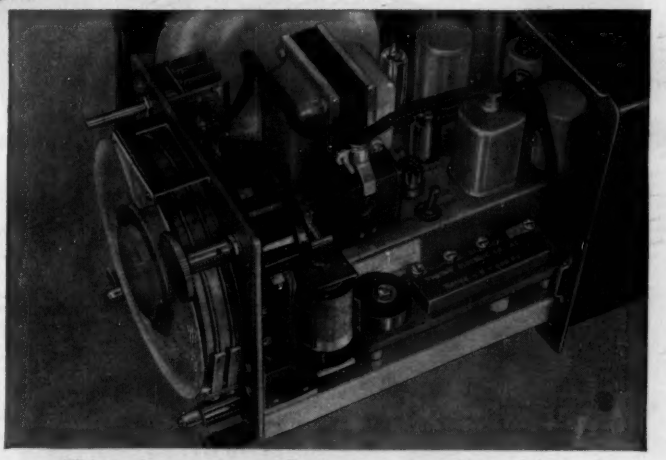
Panelcoil.....Technical data sheet 15-60 series gives complete engineering and cosa data on Dean Panelcoil. Price Bulletin 259 also available.
TL216 *Dean Products, Inc.

Steam Jacketed Kettles.....meet every processing and mixing need. Size & type for every process or product are covered in book of engineering data & specification sheets.
L181 *Groen Mfg. Co.

Steam Trap.....The 48-page Book contains additional information on trap capacity ratings, plus data on how to correctly size, install & maintain steam traps.
186 *Armstrong Machine Works

* From advertisement, this issue

Size makes the difference



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Thermo Electronic® Signaling Controller

This new, rugged, compact off-on signaling controller is simply designed, using proven components, to give you maximum accuracy, sensitivity and speed of response, in a minimum of space.

Available as a potentiometer or bridge type unit. It will automatically, continuously, dependably provide two position control of any process you require, through the use of any DC signaling transducer. Corrective action follows almost instantaneously upon detection of even a 1 microvolt signal change.

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The Thermo Electronic Signaling Controller incorporates the new high-gain relay amplifier which combines high stability with exceptional sensitivity. Stability is ± 1 microvolt, power gain, 135 decibels. Full amplifier sensitivity is used for standardizing.

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15.8" scale has large, easy-to-read numerals.

Solve your two-position control problems quickly and better with Thermo Electronic Instruments.

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Thermo Electric CO., INC. SADDLE BROOK, NEW JERSEY

In Canada: THERMO ELECTRIC (Canada) LTD., Brampton, Ontario

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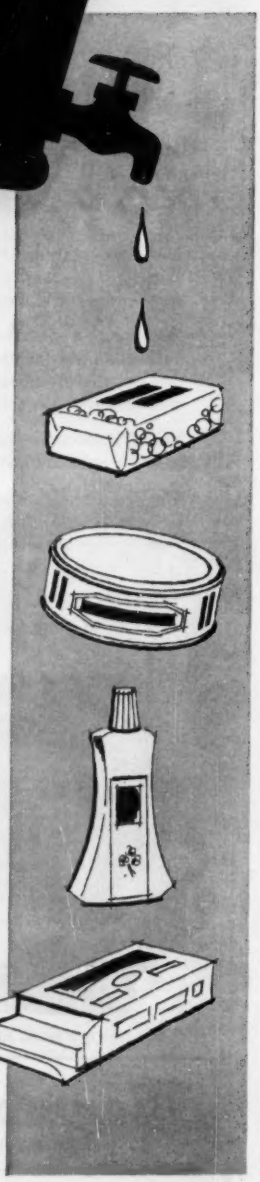

CVC Molecular Vacuum Stills

Ever stop to think that the residue material from your commercial separation process might contain profitable by-products—*extra* profits that can be recovered when you distill in high vacuum with CVC Centrifugal Molecular Stills?

Here's what some industries have recovered:

- Rosin (Abietic Acid) from tall oil pitch
- Fatty acids from vegetable oil residues
- Lanolin from wool grease
- Oils and waxes from petroleum residues

And operating costs of CVC high vacuum stills are less than 1/10¢ per pound because of lowered heat input, higher yield.

WRITE for Bulletin 3-1 on CVC high vacuum stills. Ask us about the possibility of additional profits from your separation process, and about test runs of your samples.

CVC
Consolidated Vacuum Corporation
ROCHESTER 3, NEW YORK

LITERATURE . . .

Steam Traps.....operate on a true balanced pressure principle . . . they have only one moving part. Offer positive shut-off, high capacity & rigid pretesting. Catalog 400.
179 *W. H. Nicholson & Co.

Steam Traps.....Catalog FE-310 provides information about bi-metal thermostatic and float steam traps in a wide variety of pressure ranges and body patterns.
210A Farris Engineering Corp.

Steam Traps.....Thermo-Dynamic TD-50's never block heat transfer & they remove condensate & air as fast as they collect. Information on Tracer Line Trapping.
190 *Sarco Company, Inc.

Instruments & Controls

Chart Paper.....A complete listing of replacement charts for all makes and models of recorders is given, with cross references to manufacturers' model numbers.
210B Techni-Rite Elec. Inc.

Computer.....The IBM 1620 offers solid state design, magnetic core storage and high-speed internal computing performance. Information about the 1620.
159 *International Business Machines

Computers.....The proceedings of the First Dynamic Digital Logic Conference held last March at Beverly Hills, California contains many papers of importance.
210C Computer Control Co.

Controller.....The complete story on the Dynalog Electronic Controller with full-scale spans as narrow as 5 F. is contained in Bulletin 20-10 which is available.
172 *The Foxboro Co.

Controls, Liquid Level.....Floatless, Electrode type are unaffected by acids or caustics, unaffected by pressure or temperature. A 32-pg. catalog gives specifications.
B217 *Charles F. Warrick Co.

Electronic Gauge.....Alcohol, asphalt, flour, wood pulp, corn and food starches are but a few of the endless commodities that can be measured. Information.
178 *Gilbert & Barker Mfg. Co.

Flowmeter.....New gyro-integrating true mass flowmeter measures, in pounds, fluid streams over wide fluctuations in flow rate, density, pressure, temp., & viscosity.
16-17 *General Electric Co.

Infrared Spectrophotometer.....makes possible high-resolution runs in near-infrared wavelength region between .83u and 7.65u. Information in No. 1627.
103-104i *U. S. Industrial Chemicals Co.

Meter, Stainless Steel.....is available with Direct Reading, Print-O-Meter or Auto-Switch Registers. Size 1½", capacity 100 gpm. with most liquids. Bulletin 94/10.
203 *Neptune Meter Co.

Rotameter.....in any material specifications you might want. An 8-page bulletin describes more than a dozen of the many materials available & gives meter construction.
L185 *Brooks Rotameter Co.

* From advertisement, this issue.

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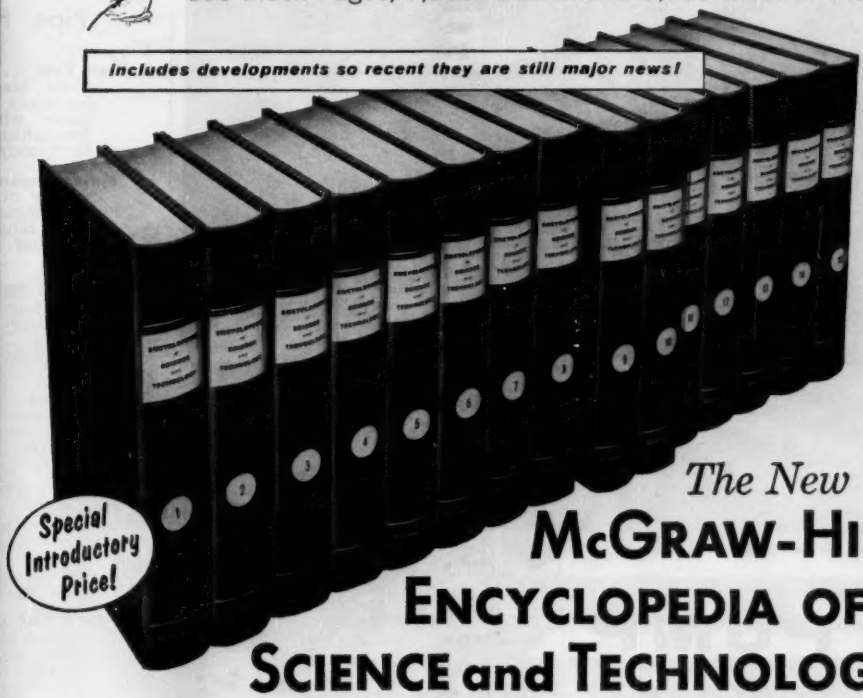

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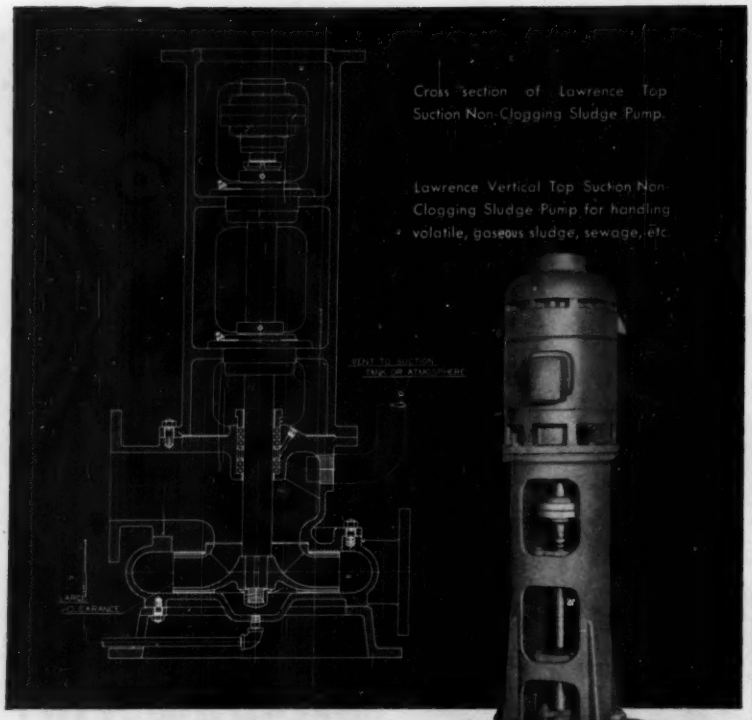
Cross section of Lawrence Top Suction Non-Clogging Sludge Pump.
Lawrence Vertical Top Suction Non-Clogging Sludge Pump for handling volatile, gaseous sludge, sewage, etc.

PUMP *volatile* SLUDGES AND SLURRIES

...without clogging
...under a low net positive suction head (NPSH)
...without gas or vapor binding

The Lawrence Non-Clogging Top Suction Pump is designed specifically to handle volatile sludges and slurries. Large clearances through the impeller and casing completely prevent clogging. Volatile gases or vapors liberated at the impeller entrance (the point of lowest pressure), are pushed up and out of the way and can be vented back to the suction tank or exhausted to atmosphere.

This type of pump can operate with a very low Net Positive Suction Head (NPSH) and never become gas or vapor bound. It is made in all metals and alloys such as: — cast iron, bronze, stainless steel, Hasteloy, etc. — depending on the material pumped.

For further details on Lawrence Non-Clogging Slurry and Sludge Pumps write for Bulletin 206-4.

LAWRENCE PUMPS INC.
371 Market Street, Lawrence, Mass.

LITERATURE . . .

Signaling Controller.....New, rugged, compact off-on signaling controller is simply designed, using proven components, to give maximum accuracy. Catalog 51-4.
209 *Thermo Electric Co., Inc.

Pipe, Fittings, Valves

Hose, Fire.....D-500 is available with white, black, yellow or red cover for ready visibility as well as for those who require color-coded fire-fighting lines. Details.
65 *Goodyear, Industrial Prod. Div.

Joints, Expansion.....made from a variety of stainless & high alloys . . . for service from 320F to 1200F. Sizes range from ½" to 35 ft. in diameter. New catalog offered.
200 *Solar Aircraft Co.

Pipe.....High impact rubber-plastic, most economical for average chemicals. Screw or solvent welded fittings. Valves ½ to 2". Bulletin 80A. is available.
174b *American Hard Rubber Co.

Pipe, Pilot.....includes a wide range of designs that handle a wide range of working pressures from 25 to 250 lbs. Handle a wide range of chemicals & abrasives.
165 *United States Rubber

Pipe, PVC.....can handle most acids, alkalies, salt solutions and alcohols. It's available in high-impact or normal impact in sizes ½" to 12" in diameter. Information.
77 *Nat'l Tub. Div. of U. S. Steel

Pipe & Fittings, Jacketed.....for conveying asphalt, rosin, wax, sulphur, gums, syrups, or other high melting point solid or viscous materials. Cat. No. 356.
B216 *Parks-Cramer Co.

Piping.....Fluoroflex-TS is available in lengths prefabricated to size, ready to install. Fittings compatible with all standard piping systems. Information.
149 *Resistoflex Corp.

Plastic Plumbing.....Equipment for a complete acid and corrosion resistant waste and drainage system, sinks, traps, pipe, fittings, etc. is described.
212A The Nalge Co.

Swivel Joints.....for practically all petrochemical & chemical services. Sizes from ¾" to 12" diameter in steel & from 2" to" 12 diameter in aluminum. Catalog.
155 *Continental-Emsco Co.

Tube, Commercial.....Brochure contains a General Commercial Tube Selector chart for Copper, Copper-Zinc series, Leaded Brasses, & Tin Brasses types of tube.
212B Scovill Mfg. Co.

Tube, Finned.....Trufin features one-piece construction and offers more BTU's per foot of tube. Available in copper, copper alloys and aluminum.
33-36 Calumet & Hecla, Wolverine Tube

Tubing, Stainless Steel.....Job-Matched is available in many sizes. grades & types. Additional information contained in Bulletin TB-1 which is offered.
110 *The Babcock & Wilcox Co.

* From advertisement, this issue

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HEATING AND COOLING COILS

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MADE TO YOUR EXACT

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To Heat and Cool Fluids

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Highly Intimate Blends in 1 to 2 Minutes

Blends while discharging; No segregation or flotation

Sturtevant Rotary Blenders start 4-way blending while charging, continue it during discharge, thus producing highly intimate, even blends of dry and semi-dry materials – within 3 to 5 minutes of start of charging.

Six *complete* blending cycles per hour are common. And Sturtevant's special action produces no particle reduction, cleavage or attritional heat – is highly effective yet gentle and safe even with explosives.

Receiving

Scoops cascade material as drum rotates. Movement forces material from both ends to middle. Thus blending is 4-way right from start of charging.

Discharging

Single gate controls charge, discharge. Blending continues throughout discharge phase. Result is no segregation or flotation — highly intimate, even blends.

Self-cleaning, dust-sealed drum; one-man accessibility

Operation of Sturtevant Blenders is self-cleaning – drum interiors are completely dust-sealed. For inspection of all models, one man simply loosens a few lugs to remove manhole cover – quickly and easily.

Nine standard models with capacities to 900 cu. ft.

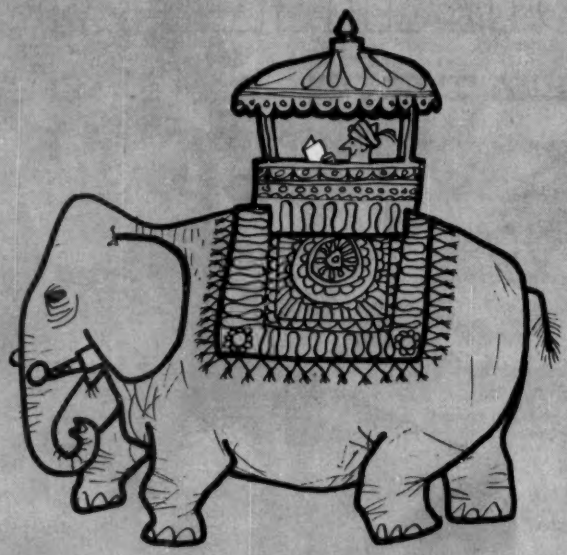
10 cu. ft. Sturtevant Blender at U.S. Steel Corp.'s new Applied Research Laboratory (Raw Materials Division) in Monroeville, Pa. This unit handles batches up to 500 lbs. — is ideal for pilot work and small runs.

One of four 450 cu. ft. Sturtevant Blenders at Celriver Plant of Celanese Corp. (Rock Hill, N. C.). These large units handle up to 20,000 lbs. batches — have a 9-year record of meeting the most exacting blending requirements.

Fully or semi-automatic, or manually controlled operation

Constructed of carbon steel, stainless steel or Monel metal, Sturtevant Rotary Blenders are engineered to fit each customer's needs – can be supplied with injector sprays and any desired control system.

For more on Sturtevant Blenders, request Bulletin No. 080B. (Bulletins also available on Mixers, Air Separators, Micronizers, Crushers and Grinders.) Write today. STURTEVANT MILL CO., 100 Clayton St., Boston, Mass.



The Maharajah of Mygosh, one of the world's wealthiest men, reads while riding an elephant.

"It gives my brain a real jog," he says. But elephants are expensive, and eat a lot. Besides, all that your engineers and managers really need, to do more business reading, is an encouraging word from you. Remember, a good place to read is a good place to think . . . and if you pay engineers and managers to think, encourage them to do more reading. Like so many successful men who read their "most useful" McGraw-Hill publications, they'll find the best place . . . home or plant, office or hammock. But wherever they read, remember, you share in the rewards.*

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Tubes, Seamless Steel.....Heavy wall seamless tubes up to 11" O.D. x 3¼" wall. Available in all low & intermediate alloy steels & austenitic stainless grades.
40 *The Timken Roller Bearing Co.

Valve.....for blending, milling, conveying applications . . . wherever powders or granulations require flow control. Product Data Sheet 18V is offered.
T226 *Patterson-Kelley

Valve, Plug Gate.....Aloyco stainless steel #66: 1200 lb. at 150 F.; 600 lb. at 500 F. Sizes available ⅛", ¼", ⅜", ½". Additional information offered.
168 *Alloy Steel Products Co.

Valves.....Type F are available flanged or screwed, in sizes from ½" to 6". 2 or 3 way design, 150 psi and 300 psi ratings. Informative Bulletin V/4b.
157 *The Duriron Co., Inc.

Valves.....Bearing-fixed Flo Ball valves are stocked with flanged or screwed ends, full or reduced port, in standard sizes from ⅛" to 10".
85-86 *Hydromatics, Inc.

Valves.....for the chemical & process industries. All kinds available; gate, globe, angle, check, "Y", relief, flush bottom tank valves, etc. Illustrated literature.
73 *The Wm. Powell Co.

Valves.....Non-lubricated Ball Valves feature full bore conduits, Teflon stem gaskets & seats that are sealed from the lading flow. Sizes ½" through 6". Catalog 1000.
29 *W-K-M Div. of ACF Industries

Valves, Ball.....The full story on the complete line of "Double-Seal" Ball Valves and accessories is contained in data sheets. Includes facts on materials, sizes, etc.
95 *Jamesbury Corp.

Valves, Control.....offer many advantages such as; minimum parts & simplicity of construction in Pneumatic Position unit, adjustable top loading, etc.
99 *The Annin Co.

Valves, Control.....A copy of an informal booklet called "25 Ways To Be Right" . . . in selecting control valve is now available on request.
12-13 *Minneapolis Honeywell

Valves, Lubricated Plug.....feature instant response because piston-like movement of plug during each lubrication prevents sticking. Catalog 39-1 & prices.
161 *Homestead Valve Mfg. Co.

Valves, Solenoid.....Conduit type and grommet type. Port sizes ⅛" and ¼ NPT. Ten orifice sizes: 3/64" through ¼". Pressures to 540 psi. New bulletin.
T215 *Marsh Instrument Co.

Process Equipment

Blenders, Rotary.....available in nine standard models with capacities to 900 cu. ft. Feature self-cleaning, dust-sealed drum. Information on Blenders in Bul. 080B.
R185 *Sturtevant Mill Co.

* From advertisement, this issue.

New...from MARSH!

Conduit-type Master-mite. Grommet-type also available.

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Designed to meet the need for positive-acting tight-seating valves for use on wide variety of media, including oxygen, hydrogen, acetylene, etc.

Two Types:
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Ten orifice sizes: 3/64" through 1/4".

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Standard with 115 V. A. C. but also available in 12, 24, 208, 230, 460 V. A. C.

Pressure to 540 psi.
Small, but with more strength in the Marsh manner. Coils never overheat. Entire assembly leak tight. Remarkably quiet operation. Cleanable without breaking connections. Used in any position. Bodies either brass bar stock or 18-8 stainless steel. All moving parts stainless. Underwriters' approved for use on oxygen and hydrogen and as safety valves.

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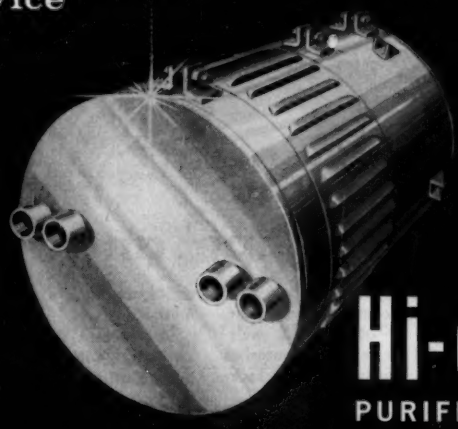
prevent product mist carryover in evaporator service



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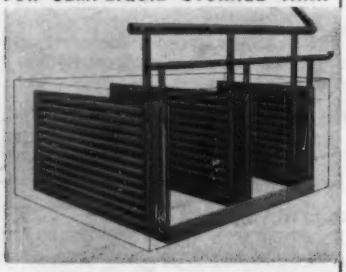
DEAN PANELCOIL FOR HEATING—COOLING

FORMS PARTITIONED HEATING UNIT FOR SEMI-LIQUID STORAGE TANK



Dean Panelcoil, because of its greater structural strength, is ideal for building into equipment as part of the shell, bottom, top, or, as shown above, as tank partitions.

In addition, Dean Panelcoil is more economical and efficient than old style pipe coil and conventional jacketing. It generally costs less to install. It takes less room, weighs less and gives fast, even heating or cooling.

Write for Data Sheet 15-60 Series and Price Bulletin 259.

DEAN PRODUCTS, INC.
1039 Dean St., Bklyn. 38, N. Y.
STerling 9-5400
Backed by 25 Years of Panel Coil Manufacturing

LITERATURE . . .

Centrifuge.....A line of centrifuges which offers broad diversification and from which the type and size best suited to your particular requirements can be recommended.
61 *The Sharples Corp.

Collector.....The Amerjet will handle heavy dust loadings of materials of varying nature with a constant pressure drop that assures accurate control. Bul. 279.
100 *American Air Filter Co., Inc.

Collector.....The Mikro-Pulsaire is available in new flexible modular units designed to meet any required capacity however large or small. Bulletin 52A-1.
75 *Mikro Products

Combustion Safeguards.....An improved line of automatic firechecks and a new design safety blowout are featured in a 12-page, two-color illustrated Bulletin CS-2.
216A Selas Corp. of Amer.

Continuous Processing.....Brochure lists agitation, classification, lime slaking, straining, centrifuging, thickening, filtration, and pumping to name only a few.
216B Dorr-Oliver Inc.

Cooker-Extruder.....The availability of an advance specification sheet on a unit designed to cook or gelatinize starches and cereal grains for expanded products is announced.
216C Sprout, Waldron and Co.

Crushing.....The 40-page edition of the "Handbook of Crushing" is very comprehensive, covering the four reduction methods and the many kinds of equipment.
216D Pennsylvania Crusher Div.

Demineralizers.....A special section devoted to the production of ultrapure water is featured in this catalog of mixed-, two-, and four-bed demineralizers.
216E Barnstead Still and Sterilizer Co.

Drying Systems.....from —60 F to 400 F., & in capacities from a few pounds to several tons are available. A new summary booklet on drying applications is offered.
22-23 *F. J. Stokes Corp.

Dust Collection System.....includes equipment for every application. Electric precipitators, mechanical collectors, bag collectors, classifiers, etc. Lit.
96 *Buell Engineering Co.

Dust Collectors.....Brochure illustrates the basic structure of the "1600" Collector. Handles high temperature and abrasive jobs. Requires almost no maintenance.
216F Dustex Corp.

Evaporators.....for all chemicals . . . acids, salts, pharmaceuticals, recovery of industrial waste. Details on the complete Buflovak evaporator line in Catalog 372.
201 *Blaw-Knox

Exhaust Systems.....The systems described are fabricated from polyvinyl chloride, polyethylene and polypropylene, and provide resistance for fume handling problems.
216G Industrial Plastic Fabricators

Extractors.....Counter-current, liquid-liquid extractors for complex solvent extraction are described in a new bulletin which is available. No. 1623.
103-104g *U. S. Industrial Chemicals Co.

Viscous Materials FLOW LIKE WATER THROUGH

Parks-Cramer Jacketed Pipe and Fittings

You can't find a better way to convey asphalt, rosin, wax, sulphur, gums, syrups, or other high melting point solid or viscous materials than through Parks-Cramer Jacketed Lines.

Steam, Aroclor, hot oil, or Dowtherm in the jacket keeps the product in an easy flowing, liquid state. Sluggish flow and plugged piping are eliminated as full jackets heat the product faster and more efficiently than by any other method.

Valves and fittings are stocked in semi-steel, with Ductile Iron, Ni-Resist, bronze, aluminum, carbon and stainless steel on order All standard types of jacketed fittings are made from 1¼" to 8" line sizes. Jacketed plug valves, 2- and 3-way, "Y" valves, strainers, check valves and relief valves are also made in sizes noted

Write for Catalog No. 356

Parks-Cramer Company
FITCHBURG 13, MASSACHUSETTS

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29 W. 15th St. WA-4-8800 New York 11, N. Y.

Filter.....Freedom from blinding is one of the several ways the new EimcoBelt filter is greatly extending the usefulness of vacuum filters. Bul. F-2053.
Cover *The Eimco Corp.

Filters.....Bulletin 76023 is designed to show the need for wall-mounted filters and then describes them in a four-page two-color brochure with technical data.
217A Ronningen-Petter Co.

Filter Press.....can be equipped with any type of plates, made of virtually any material to handle any filterable mixtures & most filter media. Details in catalog.
41 *D. R. Sperry & Co.

Hammer Mills.....feature extra heavy manganese steel liners & breaker plates, oversize shafts, massive parts & reinforcements. Facts in catalog.
27 *Williams Patent Crusher

Impactors.....Full description of Pennsylvania CDL Series Impactors, as well as other Pennsylvania Reversible Impactors contained in Bulletin 6018.
42 *Pennsylvania Crusher Div.

Lectrodryers.....Type BWC Lectrodryer works with gas generators to dry controlled atmospheres. Data sheets on metallurgical gas drying installations.
188 *Pittsburgh Lectrodryer Div.

Mill, Vertical.....offers wide application to a great variety of chemicals, pigments, food products, etc. Bul. #78 gives detailed information on superfine pulverizing.
112 *Combustion Engineering Inc.

Molecular Vacuum Stills.....Operating costs of high vacuum stills are less than 1/10¢ per pound because of lowered heat input, higher yield. Bulletin 3-1.
210 *Consolidated Vacuum Corp.

Plastic Pall Rings.....are injection molded in four sizes: ⅝", 1", 1½", and 2" in polypropylene (and on special order in rigid PVC or polystyrene).
44 *U. S. Stoneware

Process Equipment.....Bulletin contains product description and specifications on the line of laboratory and production blenders, vacuum tumble dryers, and other equip.
217B The Patterson-Kelley Co.

Process Equipment.....Steam traps, temperature regulators, and heating specialties are all listed in this 12 page condensed catalog of details and dimensions.
217C Sarco Co. Inc.

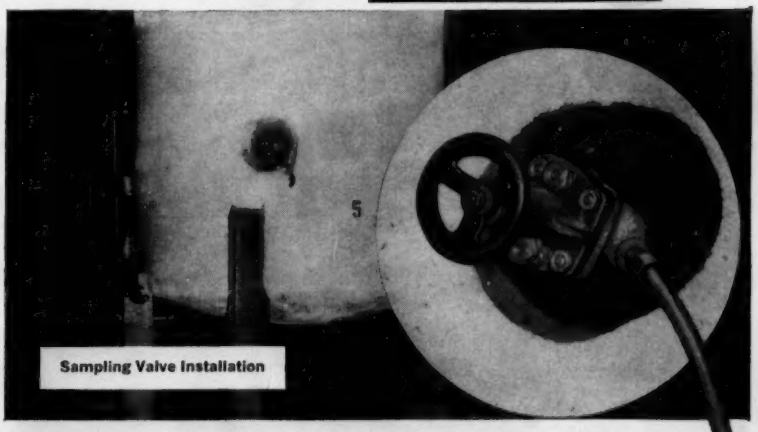
Process.....Illustrated brochure describes the Carlile Processes. Includes flow diagrams of Phosphoric Acid Plant and Ammonium Phosphate Plant. Bul. No. 160.
217D J. C. Carlile Corp.

Processing Equipment.....Votator is used for continuous polymerization reactions in numerous installations. Packaged Votator pilot systems are now available. Details.
151 *Girdler Process Equip. Div.

Purifiers.....Hi-ef prevent valuable particles from leaving evaporators & concentrators. Data on 13 types of purifiers, separators, mist extractors, scrubbers. Manual 803.
B215 *The V. D. Anderson Co.

* From advertisement, this issue.

Strahman
SCORES AT AMERICAN ALKYD!



"Just a note to let you know how satisfied we are with Strahman Sample Valves . . With the original valves . . a residue of resin remained in the valve. The Ram Type Strahman Valves . . overcame this problem; since the ram forces every bit of resin back into the kettle . . not a trace of resin remains in the valve to prevent the flow of succeeding Samples."

Says **FRED GREEN**, *Plant Supt., American Alkyd Industries.*

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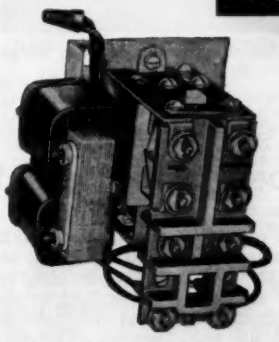
LIQUID LEVEL CONTROLS



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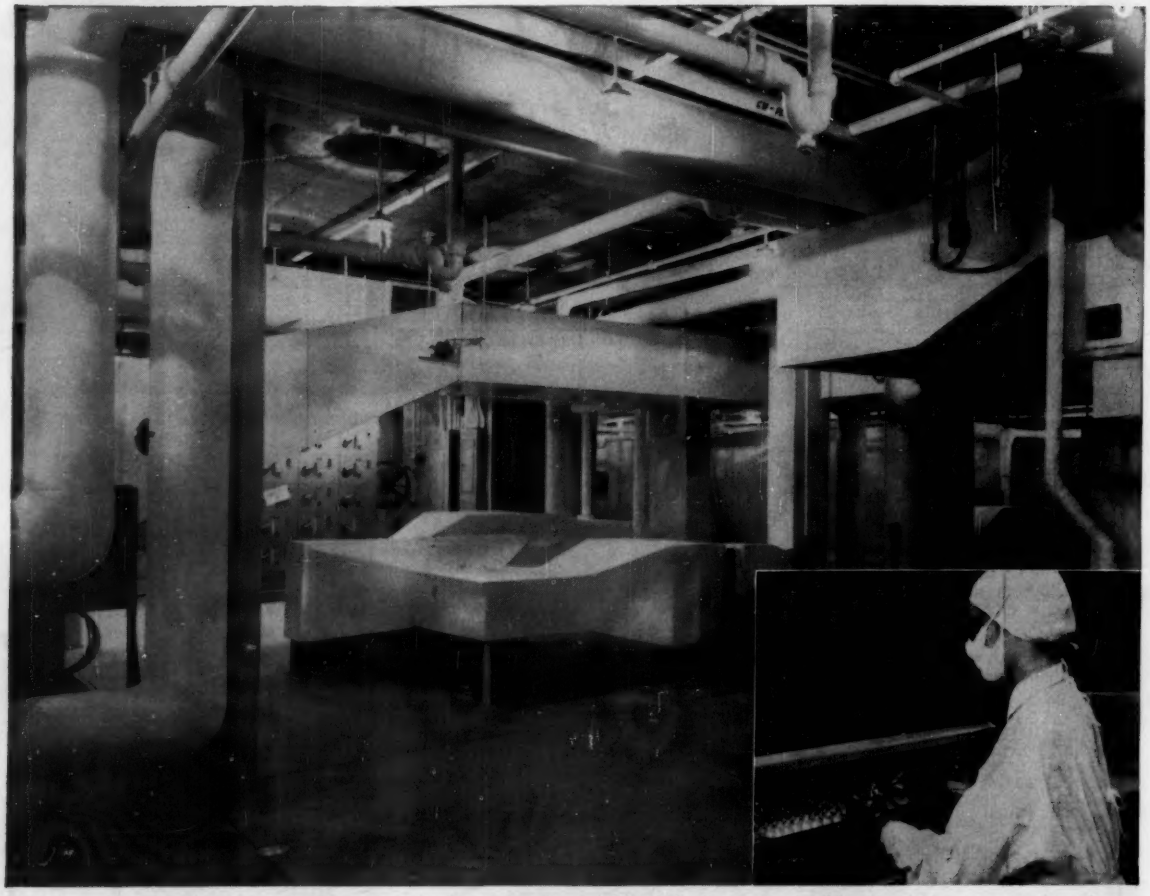
DOW | INSULATION



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STYROFOAM® prevents condensation . . . helps maintain exact temperatures!

In the production of pharmaceuticals, temperature and humidity are frequently critical . . . and sanitary requirements can't tolerate dripping pipes. That's why Styrofoam* was chosen to insulate pipes, ducts, even blowers in five separate cooling systems in a new Ortho Pharmaceutical Corporation installation at Raritan, New Jersey. Functions of the five systems range from maintaining efficient, low temperatures in cold storage rooms, to keeping one special processing room at exactly 80°F., with only 15% relative humidity.

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THE DOW CHEMICAL COMPANY • MIDLAND, MICHIGAN

Rotary Steam Tube Dryer.....Information on this type dryer contained in catalog that is available. Also contains data on other pressing, drying & cooling equip.
B226 *Davenport Machine & Foundry Co.

Pumps, Fans, Compressors

Compressors.....A wide variety of designs of compressors in sizes up to 5,000 horsepower and for pressures up to 15,000 psig. Motor or steam drive. Information.
20-21 *Chicago Pneumatic Tool Co.

Compressors.....Complete separation of cylinder and crankcase protects product. Quiet, long lasting cushioned disc-type alloy steel valves. Bul. VE-100 and VE-102.
180 *Corken's Incorporated

Pumps.....The SRL pumps are now available in gland type with positive water seal. In all sizes & capacities for a wide range of pumping applications.
53 *Denver Equipment Co.

Pumps.....Complete information on how Model 3171 can help you move uncooperative solids is contained in Bulletin 726.2 which is available.
208a *Goulds Pumps, Inc.

Pumps.....Model 3655 is available in 23 sizes with capacities to 2000 gpm, heads up to 400 ft. Pump & motor are a single, compact unit. Bulletin 710.1.
208b *Goulds Pumps, Inc.

Pumps.....Ability to resist corrosion & ability to move liquids economically & dependably are combined in these pumps. Information in Bulletin B-1b.
28 *The LaBour Co., Inc.

Pumps, Chemical.....Bulletin 212 describes type DBR rubber lined pumps. This type pump is available in 7 sizes for capacities up to 2000 gpm & heads up to 125 feet.
219A Warren Pumps, Inc.

Pumps, Progressing Cavity.....a 20-page catalog discloses the complete line of progressing cavity pumps and application data on possible uses of the pumps.
219B Moyno Pump Co.

Pumps, Proportioning.....Feed precisely metered fluids or slurries in all ratios with controlled process variables. Bulletin covers 100 series and 200 series.
R181 *American Meter Co.

Pump, Suction.....designed specifically to handle volatile sludges & slurries. Details on non-clogging slurry & sludge pumps contained in Bulletin 206-4.
212 *Lawrence Pumps Inc.

Pump, Sump & Process.....Specifications, sectional views, construction materials, performance curves, dimensions are all clearly given in Bulletin 726.2.
208c *Goulds Pumps, Inc.

Pump, Vacuum.....Complete information about the new Series H Microvac pump is available. Also a free vacuum slide calculator is offered to you.
187 *F. J. Stokes Corp.

Services & Miscellaneous

Alkaline Electrocleaner.....containing chelating agents has been introduced for heavy-duty anodic cleaning of heavily soiled steel. Information in No. 1628.
103-104j *U. S. Industrial Chemicals Co.

Chromatography.....Brochure tells how AUTOGRAD automatically provides a gradient of an infinite number of points of eluting material change rather than plateaus.
219C Technicon Chromatography Corp.

Literature List.....A 20-page list of references spanning the years 1930-1960, giving authors and publications for papers on X-ray analysis is available.
219D Philips Electronic Instruments

Nylon Fastenings.....These two-color looseleaf pages list lockwashers, polyvinyl chloride fastenings, soft-faced hammers, screws, and all sizes of hex nuts.
219E Nylogrip Products

Package Plants.....producing oxygen & nitrogen simultaneously plus a new type package Refrigeration Unit. Available in large & small sizes. Information available.
173 *Independent Engineering Co., Inc.

Publication.....Sample copies of a human relations program's publication, THE HUMAN TOUCH, are available with additional information on the complete program.
219F National Business Aids, Inc.

Refining.....A very informative 16-page brochure describes a new $30 million copper refinery which has an annual capacity of 198,000 tons of 99.9+ per cent pure copper.
219G M. W. Kellogg Co.

Respiratory Equipment.....New bulletin shows full line of canister-type masks and a canister selector table for the 62 most common industrial gas and vapor hazards.
219H Willson Products Div.

Steam Reforming Process.....This process offers high-yield ammonia plants. New booklet contains detailed engineering and economic data on steam reforming process.
25 *The M. W. Kellogg Co.

Technical Furniture.....This new 142-page catalog covers a complete line of metal laboratory furniture, fume hoods, plumbing and electrical fixtures.
219I Kewaunee Tech. Furn. Co.

Variable Programming Systems.....for automation of chemical analyses & procedures in clinical & biochemistry. Units include indexing, transfer, storage, centrifuging, etc.
103-104f *U. S. Industrial Chemicals Co.

Water Conditioning.....This data sheet discusses how the determination of steam sodium content has revealed the causes of turbine and superheater deposits, undetected before.
219J Betz Laboratories, Inc.

Well Water Systems.....Bul. 100 gives general facts & information on systems, pumps, drilling & allied services & equipment. Also special water well drilling, service work process.
145 *Layne & Bowler, Inc.

* From advertisement, this issue.

EMPLOYMENT OPPORTUNITIES

Additional Employment Opportunities on Page 220

ENCYCLOPEDIA EDITOR

Excellent opportunity for man with academic or journalistic background in physics or chemistry who wishes a career in publishing. We are looking for a permanent Encyclopedia Editor to rewrite articles and handle liaison with top men in the academic and industrial fields. Unusually attractive working environment in Charlottesville, Virginia, the perfect setting for gracious living in a University atmosphere. Liberal benefit program and relocation expense allowance.

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P-4902, Chemical Engineering
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Permanent employment with an expanding company. Excellent advancement opportunities for men with at least 10 years experience in process design of petroleum and petro-chemical plants.

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$11,000 TO $13,000

Progressive multi-plant organization seeking promotable type man with adh. rubber, fiber, plastic or polymer exp. to assume the responsibility of a free rein in initiating and developing new ideas. Client assumes all expenses.

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Opportunities available in Production Engineering for graduate Chemical Engineers with 3-10 years experience in project work. Experience in compressed gases or low temperature desirable.

Positions involve all phases of Project Engineering from economic studies through equipment procurement, installation and operations start up and offer opportunities for advancement to management in production or engineering. Some travel required.

Resumes submitted will receive our prompt attention and will be maintained in confidence.

Personnel Department

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***Write** D. F. Anspach, Sales Mgr.,*
Industrial Filtration Division,
R. P. ADAMS Co., Inc.,
Box 145, Kenmore Station, Buffalo 17, N. Y.

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Write, giving educational background, experience, age, family status and picture.

P-4917, Chemical Engineering
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Vinyl Compounder: For electrical wire compounds. Strong capability and leadership required to handle full range p.v.c. wire coating product development and control. Company expanding; offers fine growth opportunity, good salary and benefits. Metropolitan area. Reply to P-5061, Chemical Engineering stating experience.

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CLASSIFIED . . .

EQUIPMENT SEARCHLIGHT

CE's Searchlight spots the big bargains in used, resale and rental equipment. Check this issue's listings—most complete in the field—for items you need now

ANSWER

to Worthington "Hidden Value" Puzzle on Inside Back Cover

The fictitious "hidden value" is *Adjustable Roller Main Bearings.* The design of any balance opposed compressor makes roller bearings impractical from a maintenance standpoint. Worthington balanced opposed compressors use centrifugally cast sleeve bearings which can be removed for inspection or maintenance without disturbing the crankshaft or removing the connecting rod from the frame.

AGITATOR—S/S w/10 HP xpl. proof 2 spd motor, 3" shaft x 6' long w/propeller—1 HP Lightnin' 1150 RPM

SCREENS—12" x 72" S/S Ajax—20 x 84, 20 x 96 Retex—3 x 5, 3 x 10 Tyler Hummer

FEEDERS—S/S Vibrating 4½ x 24, 24 x 72 Syntron—Hardinge B Constant Weight

MILLS PULVERIZING—3 HP Sturtevant 00—10 HP Mikro 2 TH—30 HP Raymond—50 HP Mikro 3 TH w/Mikro Collector (unused)—100 HP Jeffrey 36 x 42—250 HP non-clog—450 HP Penna. SXT 14.

DRYERS, ROTARY—24" x 22', 3' x 24', 4' x 40', 5' x 50', 6' x 30', 7' x 58' all w/motor drives

DRYER, VACUUM SHELF—w/13 shelves 59" x 78", total area 356 sq. ft.

BRIQUETTING MACHINE—Komarek Greaves, 11/16 x 4-5/16 x ¼" dies w/feeder, motors, etc.

LAWLER COMPANY
Durham Ave. Liberty 9-0245 Metuchen, N. J.

CIRCLE A ON READER SERVICE CARD

WIRE US COLLECT!

RAYMOND ROLLER MILL

5 Roll High Side Model 5057. Oil Journals, Raymond Exhaust Fan, Double Cone Separator. Motors Included.

Priced To Sell

ME MACHINERY AND EQUIPMENT CO.
123 Townsend St. · San Francisco 7, Calif.

CIRCLE B ON READER SERVICE CARD

Equipment Wanted

DRYER—Continuous Apron Conveyor type. Total drying area approx. 250 sq. ft. Apron construction, stainless steel.
HAMMER MILL—#3 Mikro or equivalent.
MIXER—Double arm, blade tilting type. 300 gal. working capacity. Steam jacketed. 40 H.P. Stainless steel construction.
ROTARY AIR LOCKS—8"—12".
BALL MILL—6' x 10' Jacketed. Chrome Manganese Steel.
STAINLESS REACTOR—Min. size 6'6" x 8'. Must be built for 100 PSI pressure.
3 STAINLESS STEEL CONDENSORS—200 to 400 sq. ft. of tube surface.

Please include price information with full particulars in the first letter. Indicate if you own the equipment and where it is available for inspection.

W-4919, Chemical Engineering
Class. Adv. Div., P.O. Box 12, N.Y. 36, N.Y.

CIRCLE C ON READER SERVICE CARD

STAINLESS STEEL TANKS

24" x 45", 10 gauge, 400 PSI, type 304, ¼" pipe thread each end. *NEW,* $300 value, $99.50. Size 8½" x 18", 16 gauge, $14.50. Case of 8, $14.25. F.O.B. Baton Rouge, Louisiana.

Illinois Mfg. & Supply Co.
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CIRCLE D ON READER SERVICE CARD

SLURRY PUMPS

IMMEDIATELY AVAILABLE, 4—Lawrence Type 3-S Vertical Top Suction Slurry Pumps. MATERIAL: Carpenter 20. CAPACITY: 80-350 GPM, HEAD: 40-120 Ft., MOTOR: 10 HP, TEFC, 1200 RPM *CONDITION: Good—used*
COMPLETE SET SPARE PARTS
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Phone: EV. 3-4321

CIRCLE E ON READER SERVICE CARD

ECH SPECIAL

Abbe Eng. Jacketed 5' x 6' Ball Mill, chrome manganese steel. Price $2750.00.

EQUIPMENT CLEARING HOUSE, INC.
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From Your FIRST Source

Sparkler Filter; 560 sq. ft.

BIRD 48" Suspended Centrifuge Plow Discharge; 30 HP. 2 Speed Motor

Unused Farrell Birmingham 2 Roll Mills 14" x 30"; Top Cap; each with Uni Drive. Others.

Extruders by Royle, NRM, Allen.

Devine Vacuum Chamber Dryers from Lab. Size to Double Door 20 Shelf No. 36.

Bartlett & Snow Jacketed Batch Mixer 49 cu. ft. 6' x 21"; Scraper

Pfaudler Evaporating Pans in Stainless or Glass Lined; several sizes up to 6' diameter.

2 Double Chamber Stokes Impregnators; #5648.

Baker Perkins Heavy Duty Double Arm Jacketed Units, 300 gal., 200 gal., 100 gal. Others.

Day Cincinnatus Stainless Jacketed Double Arm Mixer, 300 gal.

2 Horizontal Type "C" Versators; 316 Stainless. Jacketed Steel Ball Mills; up to 54" x 42".

International Porcelain Lined Pebble Mills, 8' x 8' motorized with 50 HP

Jackson & Church Vertical Autoclave; 41" x 54"; Jacketed! 300 gal.; quick opening.

Condensers and Heat Exchangers absolutely the BIGGEST STOCK

Stainless Steel Columns and Towers

Tablet Presses by Stokes, Colton, Kux; many Models in Rotary and Single Punch; all sizes

Stainless Crystallizer or Pan Dryer 250 gal. 85" x 24", Jktd. Agitated

Louisville MONEL Rotary Steam Tube Dryer; 54" x 35'.

Struthers Wells STAINLESS Drum Dryers; 5' x 4' and 5' x 10'. Nickel Plated Dri Drums 4' x 4'.

2 MONEL Reactors, 2800 Gal. with Turbine Agts. Jktd. 175# ASME.

Struthers Wells Type 316 S/S 2000 Gal. Jktd. Agtd. Reactors. NICKEL Clad Reactor; 7' x 11'6".

Lancaster STAINLESS Lined Rot. Reactor; Jktd. 50" x 17'4". STAINLESS Vac. Still 755 Gal.

14 STAINLESS Pressure Tanks 700 Gal. 5' x 5'; Bottled Cover, Manhole

2 Stainless Lined 11,000 Gal. Pressure Tanks; 10' x 18'7".

2 Lehmann Amalgamators; S/S Lined; 32" x 44".

Patterson-Kelley STAINLESS Twin Shell Blenders; 30-150 cu. ft.

Oliver Dorrco NICKEL Rot. Vac. Filter; 6' x 3'; MONEL 3' x 2'.

Oliver Precoat Pressure Filter STAINLESS STEEL 5'3" x 8'. FEINC S.S. Rot. Vac. Filter 6' x 6'.

Send for FIRST Facts

FIRST MACHINERY CORP.
209-289 TENTH ST.
BROOKLYN 15, N. Y.
STerling 8-4672

CIRCLE I ON READER SERVICE CARD

CHEMICAL PLANT EQUIPMENT

***Located:* Clearwater, South Carolina**

SEPARATORS
1—High tension, Carpco, HS-218.
3—High tension, Carpco, HS-418.
5—High tension, Carpco, HT-460.
1—Magnetic, Carpco, MI-218.
1—Magnetic, Exolon type D-1A, 3.
6—Magnetic Carpco, MI-418.

DREDGE
1—6 cu. ft. Yuba bucket.
1—Screening-Dewatering & Stacking Plant.

CLASSIFIERS
1—Akins Spiral 24" dia.
2—Carpco Dewatering Spiral DS-12.

CONES
1—Settling, 30"
1—Settling, 15"

CONCENTRATORS
1—Double fan Carpco FC-2924.
1—Single fan Carpco FC-1924.

CONCENTRATING TABLES
4—Wilfley No. 6

CONVEYORS
2—18" belt, 35' 6" Barber-Greene.
1—30" belt, 51'-0".
1—Sliding belt type; 6".

DRYER
1—Hardinge Co. XFO, 36" dia. x 13'.

ELEVATORS
1—3" x 3" Buckets
1—Elevator, 22'-6" centers
1—Elevator, 23'-6" centers
1—Elevator, 26'-0" centers
1—Elevator, 29'-1" centers
1—Elevator, 23'-7" centers
4—Elevators, 24'-6" centers
1—Elevator, 29'-8" centers
1—Elevator, 26'-7" centers
1—Elevator, 23'-6" centers
1—6" x 4" Buckets
3—Elevators, 34'-6" centers
2—Elevators, 26'-2" centers

FEEDERS
1—Schaffer 20" x 6'
1—10" x 44"
1—Carpco RT—50, 12' dia.

JIGS
1—Pan American Placer type PE Single cell, 12" x 12"
1—Pan American six cell, 10" x 10"
1—Yuba Mineral, model J-1, 2 cell, 24" x 24"
16—Yuba, 4-cell, 42" x 42"

KILN
1—Ruggles-Cole Hardinge XL-2, 48" dia. X 30' long

SCREENS
1—Vibrating, Tyler Hummer, type 38, 3' x 5'
2—Allis Chalmers low head, single deck, 6' x 12'
1—12" x 24" Allis Chalmers
1—Vibrating, Tyler Hummer, type 38, 4' x 8'

WRITE **HU 4-7601** *WIRE*

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1201 W. 6th West, Salt Lake City 10, Utah

CIRCLE G ON READER SERVICE CARD

2 colloid Mills 40 HP EX. PR.

Dowtherm 225 KW

Stokes R Tablet

50 gal. S.S. Autoclave 2000 lbs. pressure

3½ gal. S.S. Autoclave 2000 lbs. pressure

Vulcanizer 60" x 9' 125 lbs.

Sweetland #2 all stainless

Stainless steel Ball Mill

Proctor & Schwartz finned drum driers

MACHINECRAFT CORPORATION
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CIRCLE H ON READER SERVICE CARD

BUY ON TERMS!

316 Stainless Steel
HIGH PRESSURE REACTORS

7—655 gal Vert Autoclaves, 900# WP, 600# Jacket With Turbine Agitator
1—728 gal (Same as above)
1—5600 gal Horiz, 6 compart. 6 Agitators, 600# WP
1—2760 gal Horiz, 3 compart. 3 Agitators, 800# WP.

MACHINERY AND EQUIPMENT CO.
123 Townsend St. - San Francisco 7, Calif.

CIRCLE J ON READER SERVICE CARD

BRILL FOR VALUES

CENTRIFUGES

Sharples C-20 and C-27 Super-D-Hydrator, 316 S.S.
Bird 18"x28", Solid Bowl, Continuous, 316 S.S.
Bird 32" x 50", Solid Bowl, Continuous, 316 S.S.
Sharples PY14, PN14 Super-D-Canters 316 S.S.
Tolhurst 26" susp. Rubber Imperforate Basket.
Fletcher 48" Suspended 316 S.S. Perforated Basket.
Sharples #16, 304 S.S., 3 HP motor.

REACTORS—EVAPS—ETC.

Pfaudler, 30 gal. Jacketed, Agitated Reactor with Condenser and Receiver.
650 gal. 304 S.S. Reactor with 100 sq. ft. Bayonet Heater.
1400 gal. Blaw-Knox, steel, jacketed, agitated Reactor.
550 sq. ft. Buflovak monel single effect Evaporator.
7500 gal. 316 S.S. Vert. Storage Tank, 7'x25', 50 psi.
750 gal. nickel clad Mixing Tank, 125# nickel coils.
500 gal. 304 S.S. Mixing Tank with nickel coils.
4000 gal. Haveg Vert. Tank 8'x12'.
7500 gal. Rubber Lined Tanks 10'x13'.
1500 gal. Stainless Pressure Tank, 5'x10', 90#.
12,000 gal. horiz. steel Pressure Tank, 7'6"x36', 200 psi.
Stainless Heat Exchangers; 1220, 786, 536, 370, 315, 250 sq. ft.
Falls Industries 100 sq. ft. Karbate Condensor.
24" dia. x 35', 304 S.S. Bubble Cap Column.

FILTERS

#5 Sweetland Filter 304 S.S. 120 sq. ft.
Oliver 6' dia. Horizontal Filter, 316 S.S.
Oliver 5' x 6' Steel Rotary Vacuum Precoat Filter.
U.S. 200 sq. ft. 304 S.S. Auto-Jet Filter.
Oliver 5'3"x8' Steel Rotary Vacuum, vaportite housing.
Oliver 3' x 2' 347 S.S. Rotary Vacuum Filter.
Feinc 5'x6' Stainless Steel Rotary Vacuum Filter.
#10 Sweetland Filters, 27 leaves, 4" centers, 250 sq. ft.

DRYERS

Buflovak Vacuum Shelf with 20—60"x80" shelves.
Devine Vacuum Shelf with 19—59"x78" shelves.
Devine Vacuum Shelf with 10—40"x43" shelves.
Buflovak 42"x120", atmospheric double drum Dryers, complete.
Devine 4'x9', single drum, atmospheric.
Buflovak 3'x10' Rotary Vacuum Dryer.
Baker Perkins 5'6"x6" Rotary Vacuum Dryer.
Buflovak 5' x 30', 3' x 7'6" Rotary Vacuum Dryers 316 S.S.
Louisville Rotary Steam Tube 6'x25', 6'x50'.
Louisville 8'x50' Stainless Steel lined Rotary Dryers.
Rotary Dryers 34"x30', 4'x40', 6'x50', 6'x60', 7'x80', 8'x87'.
Traylor 30"x18' Stainless Steel Rotary Dryer.
Link Belt, 7'5"x25', 6'4"x24", S.S. Louvre Dryers.
Atmos. Tray Dryers, 16 shelves, 40"x24".
P&S 10' wide Apron Conveyor Dryer 48' long.

MIXERS

Day Imperial 150 gal. jktd. double arm.
Baker Perkins 100 gal., jacketed, double arm, 30 HP.
Baker Perkins #16TRM, 150 gal. jktd., Vac. 60 HP.
Baker Perkins 50 gal. jacketed, double arm.
Baker Perkins 9 gal. jacketed 304 S.S. double arm.
Day "Cincinnatus" double arm, 250 and 100 gal.
Steel jacketed Powder Mixers, 225 and 350 cu. ft.
Patterson 6' dia. Conical Blender 15 HP.
3' dia. Simpson Intensive Mixer.
Stokes 21K, 304 S.S. Granulating Mixer 82 gals.

MISCELLANEOUS

Farrel Birmingham, 8" x 16", 2 Roll Chrome Plated Mill.
ISH, ISI Mikro, Pulverizers, 3 HP.
Abbe 2½" x 3' porcelain lined Pebble Mill XP motor.
Raymond 10' dia. Single with Separator.
#5 Mikro Atomizer with motor and cyclone.
Bantam Mikro Pulverizers, S.S.
No. 1 Ball & Jewell Rotary Cutter.
#18 Cumberland Rotary Cutter.
Swenson Walker Continuous Crystallizers, 24"x30' sections.
#24 Rotex Sifter, 20" x 64", Quadruple deck.
#22 Rotex Sifter 40" x 56" double deck.
#81 Day Roball Sifter 40" x 120" single deck.
Chlorimet, Durimet and Duiron Centrifugal Pumps 1½" to 6".

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NEWARK 5, N. J.
Tel.: MArket 3-7420

CIRCLE K ON READER SERVICE CARD

FOR "IMPOSSIBLE" BUDGETS

9—Lee 150 gal. S.S. Steam Jacketed Kettles. Complete w/covers.

15—S.S. Tanks. 250-350-750 and 1000 and 1250 gal. In Stock.

1—Harris 6' dia. S.S. Evaporator. C/with Barometric Leg & Pump.

2—Tolhurst 48" dia. perf. S.S. bask. Centrifuges. Mtr. Brake & Plow.

5—Rotary Flame Dryers. 2-8 x 35'; 2-6 x 50'; 1-8 x 7 x 60. ½" shell.

1—Louisville 54" x 30' Monel Rotary Steam Tube Dryer.

2—Selectro 2 x 6' Enclosed S.S. Single Deck Shaker Screens.

2—Jeffrey Flex Tooth Crushers. 1-36 x 36, and 1-24 x 20.

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CIRCLE L ON READER SERVICE CARD

OUTSTANDING VALUES!

40" rubber lined suspended centrifuge, perforated basket.
Mikros 4-TH, 3-TH, 2-TH, 1-SI.
Devine #11 vac shelf dryer.
Rotex sifters 40" x 84", 40" x 120", 1 and 2 deck

CHEMICAL & PROCESS MACHINERY CORP.
50-52 9th St., Brooklyn 15, N.Y. HY-9-7200

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PIPE

2,000,000 ft. 2"	3.50# to the foot
1,000,000 ft. 3"	7.70#
1,000,000 ft. 4"	10.98#
500,000 ft. 6"	19.00#
200,000 ft. 8⅝"	28#
400,000 ft. 10¾"	35#
75,000 ft. 12¾"	40#

All No. 3 Grade Plain End and Cleaned
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COLUMBUS 19, OHIO

CIRCLE S ON READER SERVICE CARD

CHEMICAL EQUIPMENT DIVISION

RAYMOND 5057 HI SIDE 5 ROLL MILL. FAN, SEPARATOR, CYCLONE, & MOTORS.
Raymond 3 Roll #3036 Hi-Side Mill
Buflovak 18 Shell Vacuum Shelf Dryer
1000 sq. ft. Stainless Heat Exchangers (2)
Tolhurst 40" S.S. Center Slung Centrif.
Fletcher 40" Susp. Steel Centrifugal
Sweetland #12, #10, #7 Filter Presses
30 Gal. S.S. Jktd. Autoclave 1000 PSI Int.
Shriver 30"x30" P&F 36 C.I. Chambers
Nooter 750 gal. Steel Reactor 300 PSI
Traylor 8' x 11' Ball Mill
Allis-Chal. 8'x60'x⅝" Welded Rotary Kilns
Vulcan 6'x124'x½" Rotary Kiln
Link Belt 502-16 Roto-Louvre Dryer
6' x 80' Rotary Dryer 316 S.S.
4' x 47' & 4' x 30' Rotary Dryers
Louisville 6'x50'; 6'x25' Steam Tube Dryer
Condensers 100 to 5000 sq. ft. Steel; Admir.
Dixie #5060 Mogul Hammermill
Raymond #50, #40 Impact Mills

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CIRCLE M ON READER SERVICE CARD

MODERN REBUILT MACHINERY

UNION Rebuilt Machinery Established 1912

Baker Perkins, Day, W. & P. Heavy Duty Mixers, 2½ to 150 gal. caps., Jacketed and Unjacketed.
Stokes 90-D Automatic Stainless Steel Tube Filler and Closer.
Pneumatic Scale High Speed Automatic Cartoning Line with Feeder, Bottom Sealer, Top Sealer, Wax Liner, Interconnecting conveyors.
Standard Knapp, A-B-C, Fergusen and Ceco Case Sealers.
WRAPPERS: Package Machinery, Hayssen, Battle Creek, Scandia, Wrap-King, all sizes and models.
Stokes Model DD-2 Rotary Tablet Machine. Also Models R and RB-2.
Werner & Pfleiderer 3,000 gal. and 3,500 gal. Jacketed Double Arm Mixers.
Day 50 gal. gearless Pony Mixer.
Colton 6 ft. Diam. Stainless Steel Pan.
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Raymond "O" Pulverizer.
Mikro Pulverizers, Bantam, 1SH, 2TH, 3TH and 4TH.
Fitzpatrick Comminuters.

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COMPRESSORS

No better values at any price

74 CFM	1500 PSI	6½ 3¾-13/8x7 CP. TCB3
100 CFM	150 PSI	6x7 Ing. ES-1
104 CFM	2500 PSI	6¾-4¼-1-11/16x9 IR-ES3
110 CFM	3000 PSI	Ing. GC 50BW
138 CFM	100 PSI	7x7, Ing. ES, CP & Joy
151 CFM	3000 PSI	13¾x12 Norwalk TRS-4T
288 CFM	100 PSI	9x9 Ing. Worth. CP
311 CFM	1500 PSI	10½-7⅞-3⅝x13 IR-ES3
351 CFM	350 PSI	11-5x11 CP TCB-2
401 SCFM	350 PSI	IR ESH2 (New) 12-6x11
465 CFM	100 PSI	12x11-IR-ES 1-Chic. P.T.
660 CFM	125 PSI	11¼-7x7 Joy Wn 102
686 CFM	100 PSI	14x13 Ing. ES-Chic. P.T.
877 CFM	125 PSI	17-10½x14 IR. XRB
1665 CFM	(actual) 100 PSI	C300-300H Fuller
1721 CFM	110 PSI	23-14x16 Ing. PRE2
2950 CFM	100 PSI	19x30x30x19x24 Ing. XPV

AMERICAN AIR COMPRESSOR CORP.
Chem. Road, North Bergen, N.J. UNion 5-1397

CIRCLE T ON READER SERVICE CARD

IMMEDIATE DELIVERY

MIXER: Baker Perkins size 17 200 Gal.; W & P 20 gal; J. H. Day 75 Gal.
TANKS: 1,500 Gal. totally enclosed. 15 PSI Int.; 3,800, 4,500 and 6,500 Gal. S/S lined.
MILLS: Fitzpatrick Mod D & S/S; Mikro 2TH; Prater 009; Rietz Disintegrator Mod RD 18 P.
HEAT EXCHANGERS: Foster Wheeler from 79 to 520 sq. ft. heating surface, type 316 S/S tubes & crown sheets. Priced to sell.
CENTRIFUGE: Tolhurst 20", type 316 S/S hydraulic drive.

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Schiller Park, Illinois
Gladstone 1-1500

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LOEB OFFERINGS

Autoclave: 50 gal. Struthers Wells, st. st.
Centrifugal: Tolhurst 20" st. steel (New).
Centrifugal: AT6M 60" st. st. perf.
Concentrating Table: Deister #14, 5' x 8'.
Dewaterers: Davenport 3A, bronze hd. 3 hp.
Disintegrator: Rietz RD18P, 75 hp.
Dryers: Devine 2 x 4' vac. drum, st. steel.
Dryer: Bowen lab. spray, st. steel.
Dryer: American atmospheric 24 x 48".
Dryer: Devine #7 13-shelf 60" x 7'.
Dryer: Stokes vac. shelf 22—44x40".
Evaporator: Buflovak st. st., 94 sq. ft.
Filter: Oliver precoat 12 x 2" st. steel.
Filter: Eimco st. st. drum 16" x 12".
Filter Press: Shriver 24" St. steel.
Heat Exchangers: 400 sq. ft. st. st. tubes.
Homogenizers-Dispenser: Tri-Homo #10, #4.
Kettles: st. steel with and without ag.
Dopp 150 gal. dbl. act. agitator.
Mills: Mikro Atomizer 5MA, st. steel.
Day 3-roll high speed 14 x 30".
Mixers: Dbl. and sgl. arms sigma blade.
Dry Powder, various sizes.
Pumps: Rotary, gear, centrif., vacuum.
Screen: Rotex model 41 st. steel.
Tablet Press: Stokes DD2, 23 station.
Vacuum Pans, 42" and 72" stain. steel.

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CIRCLE N ON READER SERVICE CARD

FOR SALE

Reaction kettles
Synthetic Resin Units

1—18,000 lb. charge stainless with agitator coils, condensers, etc. including new "Selas" gas heating unit. 1—18,000 lb. charge stainless with agitator coils, condensers, etc. heated by a "Trent" electric jacket.

1—10,000 lb. charge stainless with agitator coils, condensers, recei er etc. jacketed for "Arochlor" electric heater. All kettles in equal to new condition and being replaced by larger units by new resin manufacturer.

Write

FS-4920, Chemical Engineering
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CIRCLE P ON READER SERVICE CARD

VALUES GALORE—*BUY NOW*

Patterson Jack. Ball Mill 5' x 6'—25 HP.
Spiral Mixers 1000# to 3000# Capacity.
Raymond 36" Whizzer Air Separator.
Rotocone Size 16, Type W.
Sturtevant 2 x 6 Open Dr. Lab. Crusher 5 HP.
Jeffrey Traylor S.S. Double Deck Vib Screen 30" x 58".
Shriver 30" C.I.F.P. 30 Ch. 1" cake.
Raymond #3036—High Side Mill.
Tanks S.S. 100 to 600 Gals. Cap.
Autoclave S.S. 30 Gals. 1000 psi., w/Pulsafeeder.
Cyclotherm Boiler 620# hr. @250 pis.
Conveyors, Labelers, Agitators, etc.

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CIRCLE V ON READER SERVICE CARD

Mixers: 200 gal. B&P #17, VI/M dbl. arm
Mixers: 200 gal. B&P dbl. sigma blade
Agitator Mixing Tanks, Steel & Aluminum
Evaporators, 250 ton Swenson, acid bath
Sperry Filter Presses—Heat Exchangers.
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BUFFALO 32" x 90" DOUBLE DRUM DRYER

SEND FOR LISTINGS

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Sterling 8-1944

CIRCLE W ON READER SERVICE CARD

JUST PURCHASED!

2—Davenport 8′ x 60′ rotary dryers, 7/16″ welded shell, complete

2—Louisville 7′ x 70′ rotary kilns, ½″ welded shell, 1952, complete

1—Patterson 6′ x 10′ pebble mill, porcelain, jacketed

1—Buflovak 700 sq. ft. T304 SS single effect forced circulation evaporator, complete, with pumps, etc. Like new!

1—Buflovak 5′ x 30′ T316 SS rotary vacuum dryer, complete, late model

2—Buflovak vacuum shelf dryers: 110, 98 sq. ft.

STAINLESS STEEL TANKS

1—17,650 gal. horiz., T316 SS, 9′ x 35′, 40# WP
1—3700 gal. vert., T304 SS, 6′ x 17′, VAC.
1—3300 gal. vert., T304 SS, 6′ x 14′
3—2750 gal. vert., T316 SS, 7′ x 8′, 50# WP
1—2500 gal. vert., T316 SS, 7′ x 7′, 70# WP, Agit.
2—2300 gal. vert., T316 SS, 7′ x 8′, Agit.
4—2250 gal. vert., T316 SS, 7′ x 6′, 70# WP, Agit.
1—2100 gal. vert., T316 SS, 6′ x 10′
1—1900 gal. vert., T316 SS, 6′ x 8′, VAC.
12—1750 gal. vert. hoppers, T304 SS

AMERICA'S LARGEST SELECTION OF ROTARY DRYERS & KILNS — 41 UNITS IN STOCK. SEND FOR ILLUSTRATED CIRCULAR #860A

MIXERS

60—200 gal. Baker-Perkins, sigma, jkt.
1—150 gal. Baker-Perkins, sigma, jkt.
3—100 gal. Baker-Perkins, sigma, jkt., 25 HP
1—100 gal. Baker-Perkins #15-UUMM, disp. blades, 100 HP, jkt., comp. cover, motorized tilt.
1—100 gal. J. H. Day, sigma, T304 SS, 10 HP
3—75 gal. Day Imperial, dispersion
2—50 gal. W & P, sigma, jkt.
1—20 gal. Day, sigma, jkt.
1—Robinson 49 cu. ft. ribbon mixer, jkt.
1—Patterson 6′ dia Dbl. cone blender, 69 cu. ft.
1—Sturtevant #9, 150 cu. ft. rot. blender, UNUSED
1—Worthington 70 cu. ft. rotary blender
1—Robinson 2 cu. ft. conical blender, st. st.
1—Mueller T316 SS contin. mixer

CENTRIFUGALS—FILTERS

3—Sharples #C-27 T316 SS Super-D-Hydrators
2—Sharples #C-20 T316 SS Super-D-Hydrators
30—Sharples #AS-16V Inconel Super Centrif.
1—Bird 32″ x 50″, T316 SS
2—Bird 24″ x 24″ type CH monel, horiz.
1—Tolhurst 48″ dia. susp., T304 SS perf.
6—A.T.&M. 40″ dia. susp., T304 SS, 40 HP
1—Bird 40″ dia. susp., steel, imperf.
1—Tolhurst 26″ dia., susp., steel, perf.
1—A.T.&M. 12″ dia., susp., T304 SS perf.
1—Oliver 5′3″ x 8′ rotary vac. filter, UNUSED
2—Oliver 5′3″ x 3′ rotary vac., T316 SS, ASME
1—Niagara #510-28, 510 sq. ft., T316 SS filter
1—Niagara #53-36, 53 sq. ft., T304 SS filter
2—Sperry 30″ "NI-RESIST" P. & F. filter presses

CLOSE OUT!
CHEMICAL PLANT—ORANGE, TEXAS

1—Struthers Wells 3500 gal. T316 SS jkt. reactor
2—Vulcan 96″ dia. T316 SS bubble cap columns
1—Vulcan 72″ dia. copper bubble cap column
1—Vulcan 48″ dia. T304L Column, 100# WP
2—Sharples C-20 T316 SS Super-D-Hydrators
1—17,650 gal. T316 SS horiz. tank, 9′ x 36′
1—Struthers Wells 630 sq. ft. T316 SS evap.
5—800 sq. ft. T316 SS heat exchangers
2—1450 sq. ft. T316 SS heat exchangers
3—Worthington 160 ton steam-jet vac. refrig. units

MANY MORE ITEMS
SEND FOR ILLUSTRATED CIR. #1259A

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Ten Million Dollar Chemical Plant

NORTH JERSEY AREA

Type 316 Stainless Steel Equipment

7—Alloy Fabricators Type 316 SS pressure vessels, 4500 gal., complete with agitators and drives, 45 psi.

2—Alloy Fabricators Type 316 SS, 4500 gal., jacketed reactors, complete with agitators and drives.
2—Alloy Fabricators Type 316 SS, 1000 gal., jacketed kettles, 3/8" material throughout.
12—Whitlock Type 316 SS pressure vessels with coils, 270 gals.
3—Whitlock Type 347 SS pressure vessels with coils, 300 gals.
3—Type 316 SS mixing tanks, 6000 gal., complete with agitators and drives.
8—Acme Type 347 SS settling tanks with cone bottoms, 1000 gal.
1—2600 gals. Type 316 SS vertical vacuum receiver.

3—Vertical Type 316 SS activated carbon absorbers, 5'4" dia. x 16'.

1—Struthers Wells 75 gal. Type 316 SS 500 lb. pressure vessel ASME code National Board.
2—Project fabricators type 316 SS vacuum receivers, 160 gals.
2—Pfaudler 500 gal., glass lined jacketed kettles.
1—Pfaudler 20 gal., glass lined vacuum receiver.
1—Haveg, 500 gal., vacuum receiver.
2—Aluminum horiz. 5000 gal. storage tanks.
5—Pfaudler horiz. glass lined storage tanks, 5000 gals.
1—Pfaudler vertical glass lined storage tank, 5000 gals.

4—Rubber lined horiz. storage tanks, 5000 gals., working pressure 45 lbs.
16—Rubber lined vertical storage tanks, 4500 gals., working pressure 45 lbs.

2—Rubber lined vertical storage tanks 2500 gals. working pressure 45 lbs.

11—Patterson-Kelley type 316 SS condensers, 75, 84 and 235 sq. ft.
4—Type 316 SS packed columns, 18" x 11'7½", working pressure 45 psi
2—Shriver 18" x 18" SS plate and frame filter presses, 10 chambers.
5—Shriver 42" x 42" wood plate and frame filter presses, complete with hydraulic closing device, 30 chambers.

7—Buflovak Type 316 SS jacketed rotary vacuum dryers, 5'x30', complete with 25 H.P. explosion proof motors and drives

3—Type 316 SS Ter-Meer continuous type centrifuges 4' dia. bowls complete with motors.
3—Readco stainless steel horizontal blenders, 450 cu. ft. working capacity, complete with 75 HP motors
3—Mikro model 3 TH stainless steel pulverizer, complete with 40 HP explosion proof motors
1—Mikro SS bantam pulverizer, model CF, complete with ¾ HP explosion proof motor.
3—Gruendler SS, lab size, pulverizers.
3—Nash, Model TS-12, vacuum pumps, with motors.
1—Stokes Type 316 SS, jacketed, rotary vacuum dryer, 2' x 3'.
14—Copper jacketed mixing kettles, 3500 gal. each.
14—Copper jacketed rotary vacuum dryers, 8 x 10.
5—American type 316 SS blower model MD, size 27".
1—Fuller Type 316 SS, airveying system.
1—Aldrich Groff type 316 SS hydraulic triplex pumps, size 2¾" x 4" at 500 PSI.
1—Quimby type 316 SS twin screw pump with 10 hp variable speed drive.
100—Stainless steel centrifugal pumps, all makes and sizes.
2—Powell type 316 10" hydraulically operated flanged and gate valves.
2—Tyler type 38 tandem SS Hum—mer screens, size 42" x 9'8".
3—Williams type 316 SS hammer mills with 100 HP motors.
3—150 gals. type 316 SS jacketed kettles.
3—200 gals. type 316 SS jacketed kettles.
12—Type 316 SS cyclone separators, 5'2" x 10'8" overall.
500 Tons of type 316 stainless steel pipe, fittings, and valves, ranging from 2" to 6".
500 Tons of structural steel.
50—Stainless steel and aluminum hoppers, all sizes.

R. GELB & SONS, INC.
U. S. HIGHWAY 22, UNION, N. J. · MURDOCK 6-4900
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CIRCLE Y ON READER SERVICE CARD

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CHEMICAL PROCESS EQUIPMENT

1—Williams 4 roll Comet size mill, complete with all auxiliary equipment
1—General American 7' x 40' rotary dryer, 3/8" welded shell, complete
1—Sharples type 316 SS Super-D-Canter, Model PN-14.
1—AT&M type 316 SS suspended type centrifuge complete with 26" perforate basket, plow and motor

AUTOCLAVES, KETTLES AND REACTORS

2—Monel 2500 gal. jacketed autoclaves, 175# jacket, 175# internal pressure
1—Pfaudler 200 gal. glass lined jacketed reactor, complete with anchor type agitator and drive
1—Struthers Wells type 316 SS jacketed reactor, 2000 gal., complete with agitator and drive
1—Van Alst 250 gal. SS jacketed kettle, complete with SS column and condenser
2—Blaw-Knox 500 gal. steel reactors, complete with double motion agitators and drives, 50# jacket, 50# internal
1—18,000 gal. aluminum storage tank

DRYERS

2—American double drum dryers, 42" x 120", ASME N. B., complete with drives and motors
1—Hersey stainless steel rotary dryer, 3' x 16'
1—Allis Chalmers SS 6' x 50' rotary dryer, complete
10—Allis Chalmers rotary dryers, 6' x 50' and 7' x 60'
3—Link Belt steel roto louvre dryers, Model 207-10, 310-16, 604-20
1—Stokes Model 59DS steel rotary vacuum dryer, 5' x 30'
2—Louisville rotary dryers, 8' x 50', stainless steel
1—Buflovak SS jacketed rotary vacuum dryers, 3' x 15'
3—Buflovak steel jacketed rotary dryers, 3' x 15', 5' x 20', 5' x 35'
1—Traylor 4' x 40' rotary dryer
1—Western Precipitation Corp. S.S. pilot plant spray dryer, Type N-2
1—Bowen SS pilot plant spray dryer

FILTERS

3—Dorrco rubber covered filters, 6' x 2'
12—Sweetland #12 filters with 72 SS leaves
1—Niagara SS filter, Model 510-28
1—Oliver type 316 SS rotary vacuum filter, 4' x 5'
1—Oliver horizontal filter, 3'
1—GATX SS pilot plant filter, 2' x 6"
10—Shriver plate and frame filter presses, 12" x 42"
1—Shriver aluminum 30" x 30" P&F filter press, 30 chambers

CENTRIFUGES

7—Western States 40" type 316 SS suspended type centrifuges complete with perforated baskets, plows and 40 HP motors. Year built 1953
1—AT&M 48" SS suspended type centrifuge, complete with plow, motor and imperforate basket
1—Fletcher 48" center slung SS centrifuge, complete with perforate basket and motor

THE GELB GIRL—AUGUST 1960

4—Tolhurst 40" center slung rubber covered centrifuges, with perforate baskets and motors
2—Fletcher 40" center slung rubber covered centrifuges with perforate baskets and motors

MIXERS

1—Cleveland SS double cone blender, 85 cu. ft. complete with drive and motor
2—Sturtevant #7 dustite rotary batch blenders, NEW
15—Robinson type 304 SS horizontal blenders, 255 cu. ft.
1—Baker Perkins Size 20, 2000 gal. double arm jacketed vacuum mixer with double naben blades
1—Baker Perkins Size 16, Type UUEM, 150 gal. jacketed double arm dispersion type mixer, complete with compression cover and 100 HP motor
2—Baker Perkins 20 gal. SS. jacket vacuum double arm mixers
1—Baker Perkins Size 4, laboratory mixer, sigma blades, 1 gal. total capacity
1—Banbury #1 mixer, chrome plate rotors, with 50 HP motor
1—Stokes SS granulating mixer, Model 21 J

MISCELLANEOUS

1—Vulcan SS bubble cap column, 4' x 25 plates
1—Badger type 316 SS bubble cap column, 42" dia. with 11 trays
1—Badger type 316 SS bubble cap column, 36" dia. with 8 trays
1—Struthers Wells type 316 SS heat exchanger, 330 sqft.
1—Condenser Service type 316 SS heat exchanger, 350 sq. ft.
3—Badger type 316 SS heat exchangers, 500 and 600 sq. ft.
1—Downington type 316 SS heat exchanger, 750 sq. ft.
2—Swenson type 316 SS vacuum crystallizer, 3'6"x12', 2'x12'
3—Williams type 316 SS hammermills, Model AK
1—Sprout Waldron Model 501-D pelleter
1—Ross 6" x 14", 3 roll paint mill, complete
1—Stokes #412F vacuum pump, complete

2—2000 gal. type 304 SS vertical storage tanks
1—Richmond Engineering type 316 SS 40 cu. ft. horizontal double ribbon blender
1—Oliver stainless steel rotary pressure precoat filter, 5'3" x 8'
4—Davis Engineering Carpenter 20 heat exchangers, 125 sq. ft., NEW

R. GELB & SONS, INC.
U. S. HIGHWAY 22, UNION, N. J. · MURDOCK 6-4900
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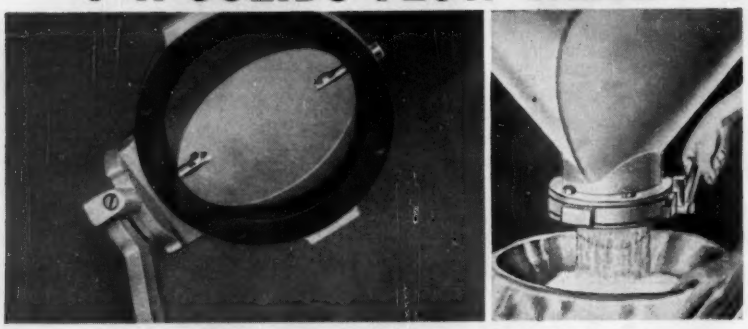
ALL-NEOPRENE-STAINLESS P-K SOLIDS FLOW VALVE



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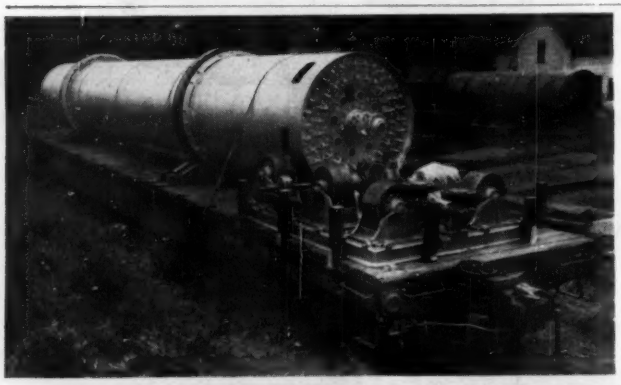
Install this compact P-K valve for blending, milling, conveying applications – wherever powders or granulations require flow control. All parts, including neoprene liner, are interchangeable and easily replaceable in field. Precision machined.

Among accessories – air actuator, 90° rotation; adapter to fit P-K valve to existing equipment; plastic bag adapter; positive pressure of vacuum tight cover. Sizes 6", 8", 10", 12".

Send for Product Data Sheet 18V– today.

Patterson Kelley

Chemical and Process Equipment Div., East Stroudsburg, Penna.



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Another "DAVENPORT" Steam Tube Dryer ready for shipment. This unit will operate on spent distiller's grains in one of the larger distilleries in Kentucky.

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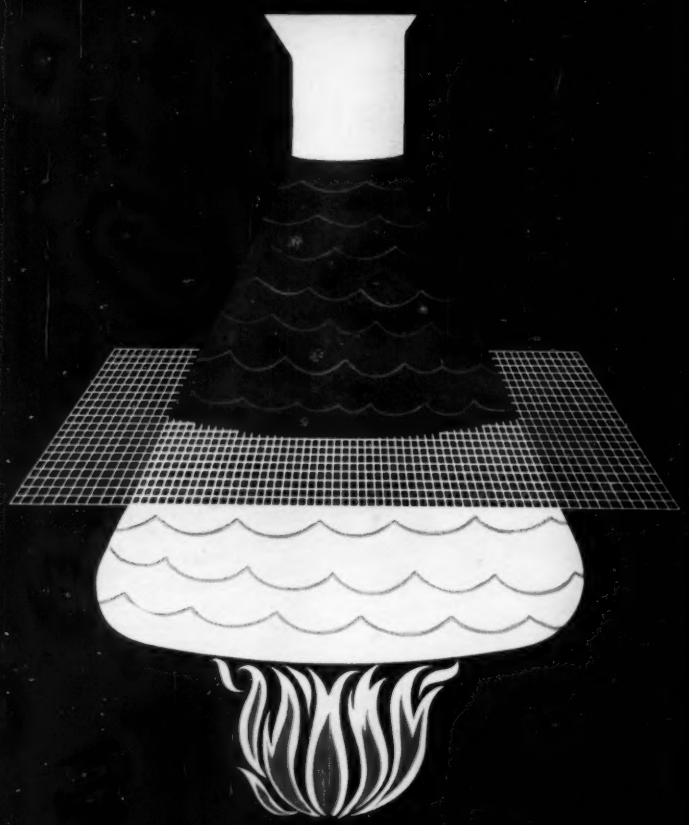

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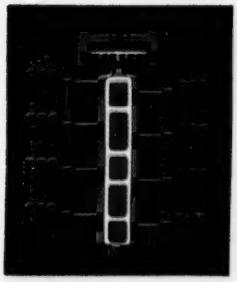
WILL YOUR NEXT BALANCED OPPOSED COMPRESSOR HAVE ALL OF THESE "HIDDEN VALUES"?



No, it won't! Even if you choose a Worthington compressor, you'll get only 23 of the 24 "hidden values" pictured below. (Just to pique your interest one is fictitious. For identification of the phony feature, see page 220.)

Compressors should be evaluated on performance, we think you'll agree. But performance is determined by factors which aren't easily checked against service conditions and data. These are the factors we call "hidden values." It will pay you to evaluate these values the next time you specify a compressor. Worthington Corp., Clinton Street and Roberts Ave., Buffalo 5, N. Y. 36-8

WORTHINGTON

OPTIC COMPARATOR is used to check connecting rod bolt threads for uniform angles, lead and form.

WIRE ALIGNMENT during assembly using electronic equipment minimizes field alignment problems.

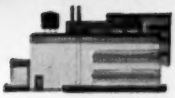
FACTORY ASSEMBLY of intercooler and interstage piping reduces installation problems and costs.

COMPOSITION TEST determines constituents of molten iron in each ladle before any casting is poured.

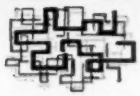
HONING of connecting rod crankpin and crosshead pin ends results in tighter fits, no loose shells.

INTEGRATED DIV. includes foundry, manufacturing, sales, service and engineering in one location.

ULTRASONIC TEST—an advanced method of examining certain critical parts for internal quality.



$1,000,000 ADDITION TO LABORATORY assures sound equipment designs based on actual research.



ANALOG/COMPUTER simulates wide range of actual operating conditions for optimum design analysis.

PROFILOMETER inspection of highly finished parts assures easy break-in and long life.

KOLENE PROCESS removes impurities from bearing shell that weaken bond between it and babbitt.

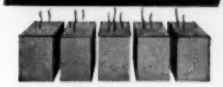
CAST-IN LUBE OIL SYSTEM with internally drilled oil passages eliminates crankcase "plumbing."

MAGNAFLUX AND MAGNAGLO inspections are widely used to expose surface imperfections.

FINISHED GROUND BEARING SHELLS provide positive full-contact backing for long life.

DESTRUCTION TEST of complete compressor cylinders verifies engineers' design calculations.

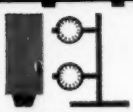
REMOVABLE DOWEL locks piston rod to crosshead—prevents turning due to loosened crosshead nut.



PARCO-LUBRITING of critical wearing surfaces completely eliminates most start-up scuffing problems.

FEATHER VALVE—industry's preferred compressor valve—is efficient, quiet, and low in maintenance.

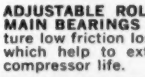
STEEL TIE BAR, keyed and bolted in place, strengthens frame and maintains the original alignment.



CROSSHEAD SLIPPER ADJUSTMENT within one-thousandth of an inch assures much longer packing life.

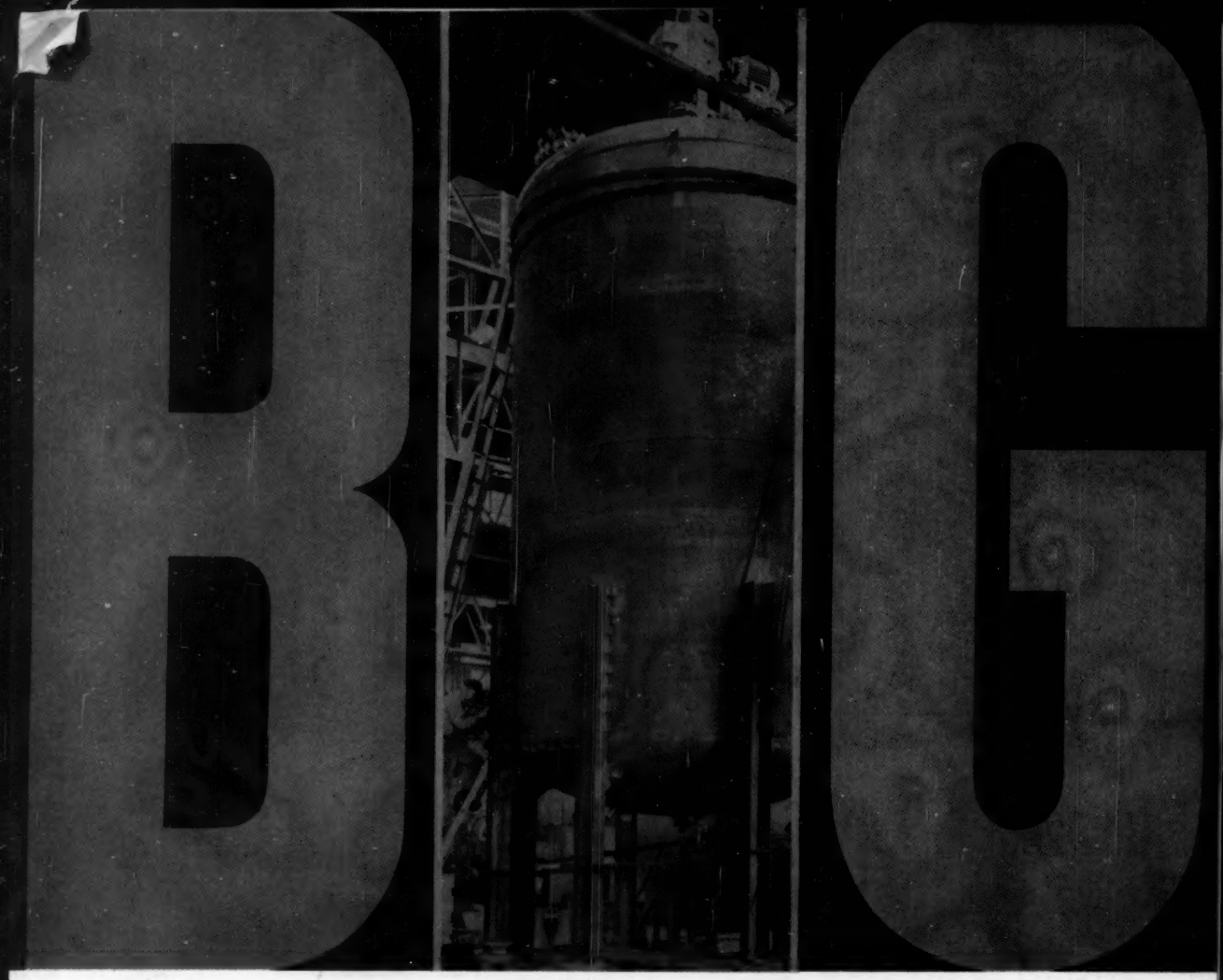
THERMODYNAMICS SECTION analyzes each application to size unit and determine its performance.

SALES AND SERVICE INTEGRATION recognizes kinship of one to the other. One man administers both.



ADJUSTABLE ROLLER MAIN BEARINGS feature low friction losses which help to extend compressor life.

AIR CONDITIONED GAUGE ROOM has master gauge blocks constantly used to check instruments.



GLASTEEL TANKS

FLUIDICS* at work
This agitated tank is 35 feet high, weighs 10 tons and has a capacity of 17,000 gallons.

The construction is Pfaudler® Glasteel—glass inside, for corrosion resistance; steel outside for strength. It costs *less* than you would pay for a stainless tank of equal capacity.

You name the size. Admittedly, tanks like this are not standard items. Yet, we can and will deliver Glasteel in vessels sized and designed to fit your needs.

For example, we recently supplied a 7,150-gallon agitated reactor for processing monochloracetic acid and alcohol at 158° F., with jacket designed for 25 psi pressure at 350° F.

Then there are the really big 35,000-gallon Glasteel storage tanks, a very common sight on our production lines.

It takes special skills and facilities in fabrication to make such vessels. We welcome the BIG ones. And, again, with Glasteel, big size actually means prices smaller than you pay for many other materials of construction.

Protects purity. The 17,000-gallon tank pictured will be used by The Borden Chemical Company for PVC production. Glasteel has become the *industry standard* for polymerization equipment, since it won't contaminate or discolor any of the materials used or produced. Nor will it act as a catalyst. This equipment is flexible too, and can be changed from one polymer to another in tune with market trends.

Reduced down time. The surface of Glasteel is abrasion-resistant and smoother than the most highly polished metals. Very little adheres to it. What does you can quickly wash away between batches. Result: more output of product per day than with other materials.

Facts for your files. Bulletin 932 covers Pfaudler Polymerizers. Bulletin 975 details the economies of and specifications for Glasteel Storage. We'd be happy to send copies, or answer questions about BIG Glasteel tanks. Write to our Pfaudler Division, Dept. CEB-80, Rochester 3, New York.

*FLUIDICS is the Pfaudler Permutit program that integrates knowledge, equipment and experience in solving problems involving fluids.

PFAUDLER PERMUTIT INC.

Specialists in FLUIDICS...the science of fluid processes